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UNITED STATES DEPARTMENT OF AGRICULTURE
U.S. Bureau of Agricultural Engineering, Division of Drainage
S. H. McCrory, Chief

1932 Progress Report on

ENGINEERING EXPERIMENTS CONDUCTED AT THE

SOIL EROSION EXPERIMENT STATION

near

GUTHRIE, OKLAHOMA

In cooperation with the U.S. Bureau of Chemistry and Soils,
The Oklahoma A. and M. College and the
Guthrie Chamber of Commerce, Guthrie, Oklahoma.

by

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T A B L E O F C O N T E N T S

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L I S T O F F I G U R E S

Number	Title
10	- Cumulative rainfall and rates of rainfall and run-off for terraces 700 feet long with 4" grade per 100', and different vertical spacings as follows: 1-A and 6-A = 2 feet, 2-A and 5-A = 3.5 feet, 3-A and 4-A = 5 feet. Rain of October 3, 1932.
11	- Deposit of silt in channel of Terrace 6-B, July 7, 1932.
12	- Gullies between Terraces 2-C and 3-C caused by concentration of water from contoured rows to natural depression. June 8, 1932.
13	- Terrace profiles, Field "C".
14	- Erosion in channel of 3-C, 50 feet from outlet. Terrace is 1,500 feet long with constant grade of 6 inches per 100 feet. June 8, 1932.
15	- Cumulative rainfall and ratesof rainfall and run-off for terraces 1,500 feet long with 3.5' (approx.) vertical spacings and grades as follows: 3-C = 6" per 100', 4-C = 4" per 100', 5-C = 2" per 100', and 6-C = level. Rain of June 24, 1932.
16	- Cumulative rainfall and rates of rainfall and run-off for terraces 1,500 feet long with average vertical spacing of 3.5 feet and grades as follows: 3-C = 6" per 100', 4-C = 4" per 100', 5-C = 2" per 100', and 6-C = level. Rain of October 3, 1932.
17	- Cumulative rainfall and rates of rainfall and run-off for terraces one half mile long with average vertical spacings of 3.9 feet. Grades and soil are as follows: - 2-C = 0" to 6" per 100', 1-C = 0" to 4" per 100', both on virgin soil. 2-B = 0" to 6" per 100', 3-B = 0" to 4" per 100', and 4-B = 3" per 100'. All three on eroded soil. Rain of June 24, 1932.
18	- Cumulative rainfall and rates of rainfall and run-off for terraces one half mile long with average vertical spacings of 3.9 feet. Grades and soil are as follows: 2-C = 0" to 6" per 100', 1-C = o" to 4" per 100', both on virgin soil. 2-B = 0" to 6" per 100', 3-B = 0" to 4" per 100', and 4-B = 3" per 100'. All three on eroded soil. Rain of October 3, 1932.

Number	Title
19	- Terrace profiles, Field "E", Red Plains Soil Erosion Experiment Station.
20	- Composite cross sections of terraces built with various machines on the Faulkner and Allen Farms, Guthrie, Oklahoma.
21	- Wheatland one-way disc plow working in moist soil on the Elliott farm. The discs are badly clogged with the sticky earth and are no longer efficient as dirt movers.
22	- Composite cross-sections of terraces built with various machines on the Elliott farm near Guthrie, Oklahoma.
23	- John Deere tractor and Wheatland plow crossing Terrace 3-C at angle of 45°. The terrace ridge is extremely dry and hard. Note that two wheels are off the ground and that the center discs are cutting very deep, resulting in damage to terrace. June 18, 1931.
24	- Tandem disc and two section harrow working terrace ridge. Note overhang on ridge top.
25	- Do-All tractor cultivator on top of Terrace 5-B, cultivating row on each side ridge top. Outer shovels are out of ground, June 18, 1931.
26	- Do-All cultivator working parallel to Terrace 5-B on lower side of terrace. Skew is so great that tractor wheel must rest on crop row to prevent plowing out crop of beans. June 18, 1931.
27	- Do-All tractor cultivator crossing Terrace 5-B at right angle. Tractor wheels are just over ridge top. Beam is resting on ground and front cultivator shovels are buried. June 18, 1931.
28	- Seven foot binder cutting oats in channel of Terrace 3-C. Note height of cutter above channel.
29	- Caterpillar 15 Tractor and seven foot binder crossing at right angle to terrace ridge. Note that cutter is striking ridge top.
30	- Brush dam at lower end of Gully G. Note how brush has rotted and fallen in after three years of service. April 8, 1932.

Number	Title
31	- Poledam after three years service located at lower end of Gully F. Note that fill back of dam is level with notch. April 8, 1932.
32	- Failure of pole dam at lower end of Gully F. This dam was installed in 1929, July 7, 1932.
33	- Woven wire dam in Ravine A. Note the accumulation of silt behind the wire. April 8, 1932.
34	- Rock dam laid with mortar to height of four feet in Ravine A. May 27, 1932.
35	- Terrace outlet protective device with wide notch, constructed of pyramided poles at outlet of Terrace 8-B. Filling occurred during spring of 1932. October 10, 1932.
36	- Terrace outlet protective device constructed of loose rock chinked with straw at end of Terrace 6-B. All filling occurred during spring of 1932.
37	- Cumulative rainfall and rates of rainfall and run-off for small watersheds with different characteristics as follows: Plot L = 5.6 acres wooded; Plot J = 5.3 acres gullied grass land; Plot 13 = 3.6 acres, cultivated and not terraced; Plot 15-A = 3.1 acres, cultivated with five level terraces; Ravine A = 35.0 acres of terraced land. Landslopes vary from 3.5' to 5' per 100'. Rain of June 24, 1932.
38	- Cumulative rainfall and rates of rainfall and run-off for small watersheds with different characteristics as follows: Plot L = 5.6 acres wooded, Plot J = 5.3 acres gullied grass land; Plot 13 = 3.6 acres, cultivated and not terraced; Plot 15-A = 3.1 acres, cultivated with five level terraces, Ravine A = 35.0 acres of terraced land. Landslopes vary from 3.5' to 5' per 100'. Rain of October 3, 1932.

P L A T E

		Number
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LIST OF TABLES

INTRODUCTION

Study of the economical control of soil erosion in its various phases is the primary objective of the Bureau of Agricultural Engineering on the Red Plains Soil Erosion Experiment Station. Investigations to determine the rate and per cent of run-off from the terraced and unterraced farm lands, coupled with determinations of the soil losses from the same areas, are of paramount importance. These investigations are expanded to show the effects of various land slopes and soil conditions. The data from such experiments will ultimately define a proper and economical basis for decisions regarding the grade, size, vertical spacing, and permissible length for terraces. In addition they will, by comparing soil and water losses from terraced and unterraced areas, serve to demonstrate the economic necessity for terracing farm lands. The efficacy of terraces as conservers of soil moisture, by such design that all rain water is retained, is studied on various soil conditions. Terraces are studied in relation to their effect upon normal farm operations when conducted either parallel to or across the terrace ridges. All operations are conducted with modern farm machinery, the data obtained thus dictating desirable changes in machinery to be used on terraced land, and furnishing a means whereby the most desirable shape of terrace cross section may be determined for various land slopes.

The first questions asked by the landowner interested in terracing concern the probable cost and most efficient methods of terrace construction. Such inquiries can be answered definitely only through experience gained under a wide variety of conditions. Accordingly, accumulations of data showing the cost of building and maintaining terraces on different slopes, soils and surface conditions, are being made and will serve the threefold purpose of pointing out improvements in terracing machines, developing efficient methods of construction, and establishing a definite cost index upon which accurate estimates may be based. Experimental effort is also being directed toward the design of terrace outlet protection devices which may be cheaply installed and toward the development of methods for the disposal of water from terraced fields. Check dams and soil saving dams, in their role of halting and reclaiming gullies, are studied extensively for possible improvements in design and construction.

Station Farm

The Red Plains region covers most of the western half of Oklahoma, northwest central Texas, and a small portion of southern Kansas. The Red Plains Soil Erosion Experiment Station Farm, selected as typical of the more erosive phases of this region, is located 5 miles south of Guthrie, Logan County, Oklahoma. This farm, comprising 160 acres of rolling land, was opened under the Oklahoma Homestead Act of 1889, during

the famous run of that year. Severe erosion had taken place at the time the farm was leased for experimental use.

Topographic and soil surveys show that the slopes on the farm vary from two to eight per cent with a maximum difference in elevation of 78 feet, and that two principal soils are available. Kirkland fine sandy loam soil occurs, (see farm map, Figure 1) on the smoother divides in the central, south central, and northwestern sections of the farm. The Vernon fine sandy loam soil occurs on the slopes forming the remainder of the farm.

An erosion survey of the farm proves that, of 70 acres of cultivated land, 68 acres are affected by erosion while the other two acres are buried under from 6 to 24 inches of erosional debris. Soil planation over 48 per cent of the cultivated land varies from one to ten inches. The remainder of the cultivated land, with the exception of the buried two acres, is completely denuded to depths varying from 10 inches to several feet.

Rainfall and Run-off Measurements

The intelligent design of any channel intended to convey excess rainwater from the fields must be based upon a definite knowledge of the intensity and amount of rainfall and run-off.

Three recording rain gages located as indicated on the farm map (Figure 1) measure the amount of rainfall at any instant to the nearest 0.01 inch and the time to the nearest minute can be estimated from the record charts. The daily rainfall records of these gages for the years 1931

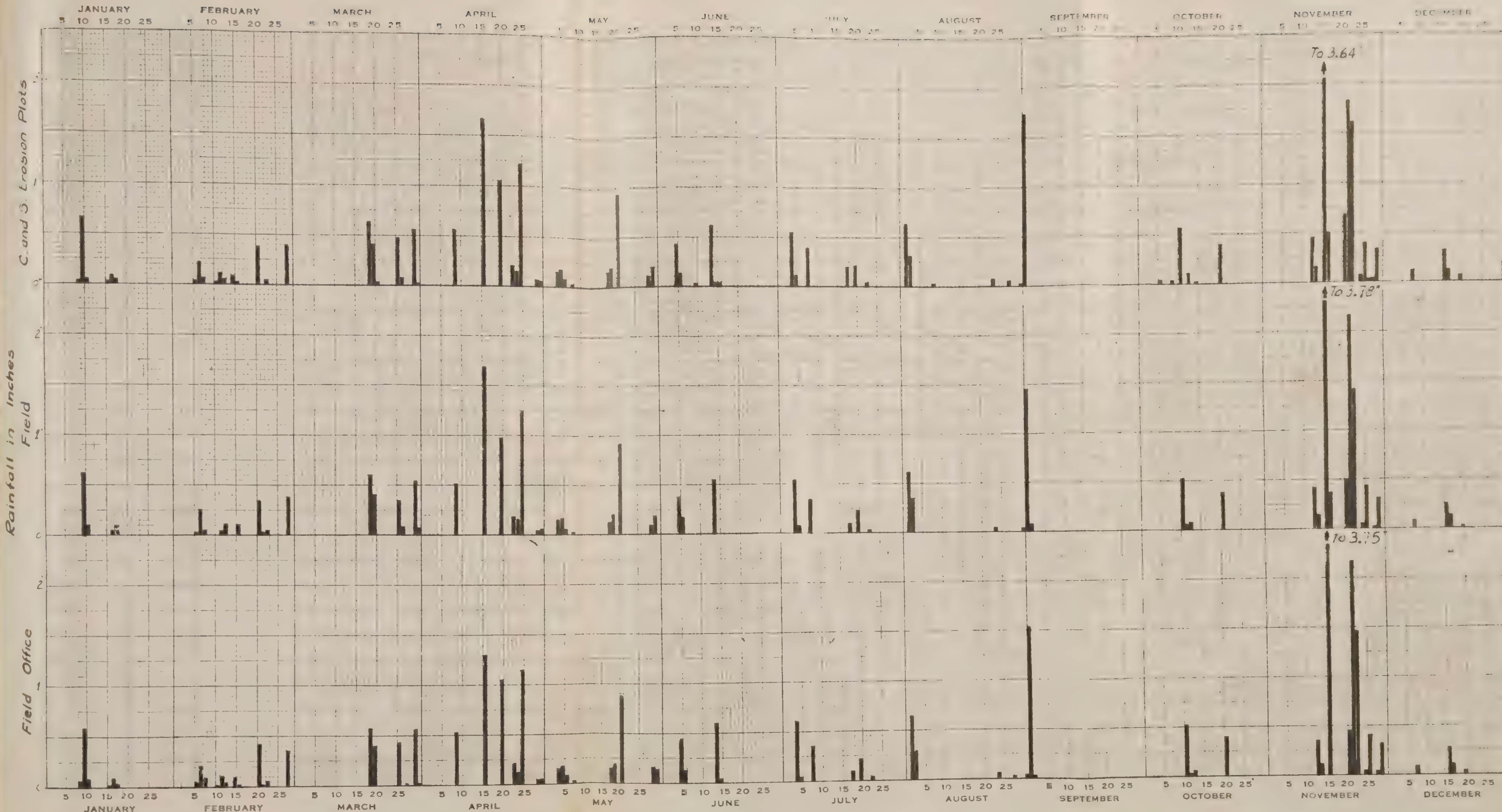


Fig. 2 -Record of daily precipitation on the Red Plains Soil Erosion Experiment Station for the year 1931

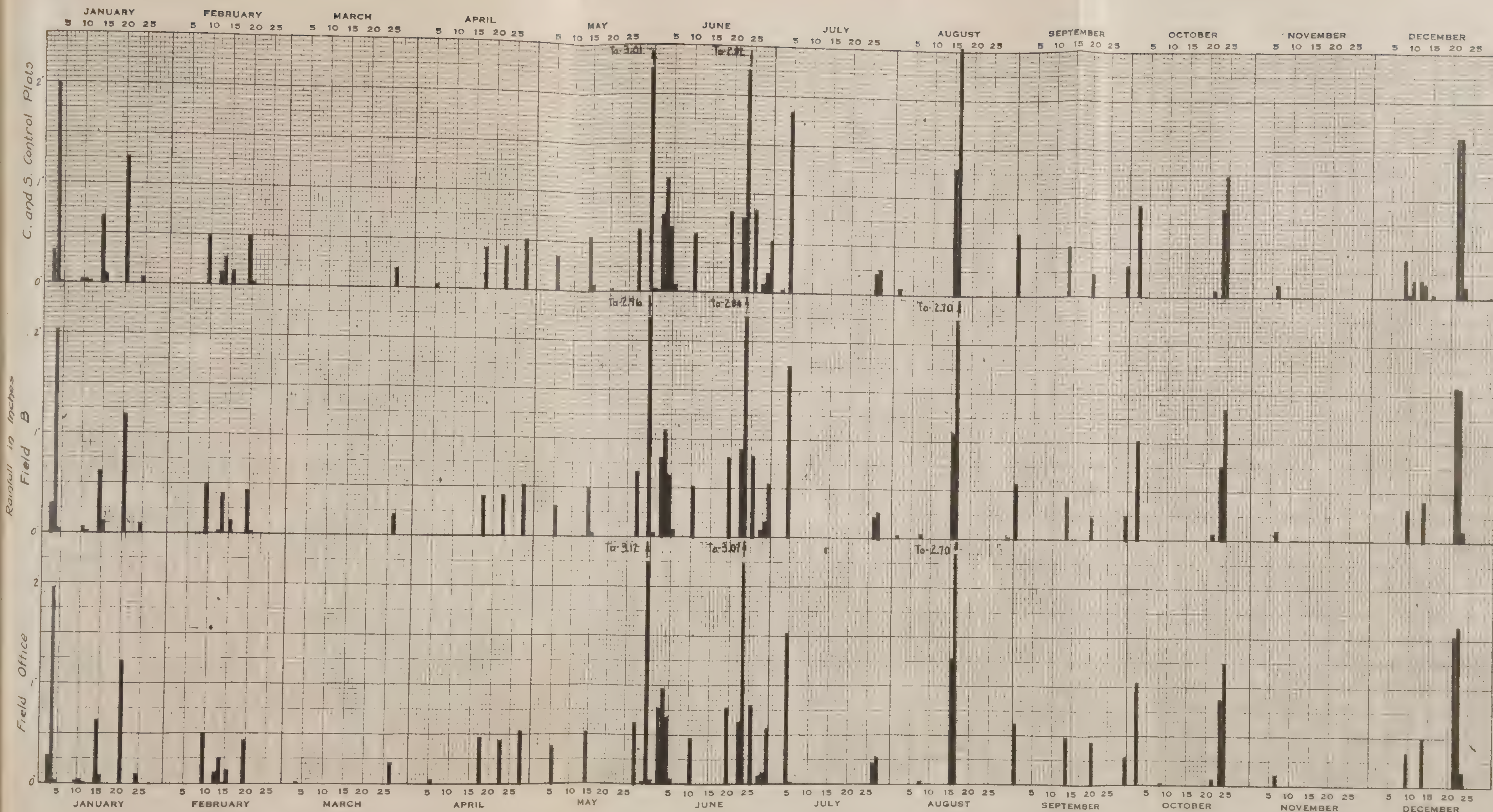


Figure No. 3 -Record of daily precipitation on the Red Plains Soil Erosion Experiment Station for the year 1932

and 1932 are given in Figures 2 and 3. Further checks of the distribution of rainfall over the farm are made by standard weather bureau rain gages located at various points, see map (Figure 1).

The measurement of run-off is accomplished by units consisting of a Parshall measuring flume combined with an automatic water level recorder (Figures 4 and 5). The charts from these recorders indicate the water stage at any instant to the nearest 0.01 foot and the time to the nearest minute. Tables giving the discharge of the Parshall measuring flume for any standard width at any given waterstage have been prepared from extensive laboratory tests and are used in conjunction with the charts from the automatic water level recorders to prepare hydrographs of run-off. The selection of the Parshall measuring flume was made in preference to other flow measuring instruments for the following reasons:

1. The flume measurements are not appreciably affected by the velocity of approach and as a result it is not necessary to store water to eliminate this factor.

2. A deep outlet channel below the flume is not needed since the discharge is affected only by extreme backwater conditions.

3. Theconcentration of water and consequent in~~xx~~ crease in velocity at the throat of the flume tends to carry away any soil or drift which is brought to this section by the slow moving water in the terrace channel.

Figure 4: Parshall measuring flume of two foot throat width with wing walls and recorder shelter.

M e a s u r e m e n t s o f S o i l L o s s e s

Measurements of the amount of soil loss are made with the Ramser silt Sampling Device. A wooden box (Figures 6 and 7) is used to trap all the heavier material in the run-off water. The size of this box varies with the width of the Parshall measuring flume as follows:

> For a flume of one foot throat width the box is 16 feet long, five feet wide and two feet deep below the crest of the outlet weir; and for a flume of two foot throat width the box is 16 feet long, 8 feet wide, and 2 feet deep below the crest of the outlet weir (Figure 6). The amount of material dropped in the box is measured directly while the amount escaping in the water over the rectangular weir at the outlet end of the box is determined by a sampling device which takes a proportionate amount of the discharge at any stage of flow through a notch in the side of the box (Figure 6). The water from this notch of 1/2 inch width enters a divisor box where it is again divided by means of two small weirs. The water through the larger or 3 inch weir is wasted while that from the 1/2 inch weir is conducted into a storage tank (Figure 7). The silt content of the water in the tank is determined and applied to the total volume passing over the outlet weir to determine the amount of dry soil in the discharge water. This figure when added to the material caught in the box gives the total amount of soil loss from the drainage area for any particular rain.

Figure 6: Silt box and silt sampling unit for two foot Parshall measuring flume. Divisor box, waste weir, and sample storage tank in right front of view.

Figure 7: Silt box and silt sampling unit for two foot Parshall measuring flume. Note sampling slot and screen.

Climatological Data

Distribution of rainfall over the years 1931 and 1932 is shown in Figures 2 and 3. The total rainfall of 27 inches on the station farm during 1931 is approximately six inches below the mean. At the first of November the rainfall deficiency amounted to about 12 inches but a total precipitation of 10 inches during the remainder of the year cut this deficiency in half. The abnormality of the rainfall year 1931 is further emphasized when consideration is given to the fact that the spring months are normally those of greatest rainfall.

The rainfall occurrence during 1932 was more nearly normal, although there was an excess of 3.65 inches above the yearly mean. June was a month of great excess rainfall with other marked excesses in January, July and December. Deficiencies occurred in March, April, September and November. The rainfall for the other four months of the year was reasonably near the average. The 14.00 inches of intense rainfall which fell during the period May 31st to July 5, 1932 constituted 39 per cent of the year's rainfall and produced approximately 91 per cent of the year's soil losses.

Monthly wind movement and average velocity in miles per hour for the four years of record are given in Table No. 1. These averages for the year 1932 were below normal.

Crops

The Dixie three year rotation of corn, oats, cotton, combined with green manure and cover crops constitutes the basic farming system used

T A B L E   N o. ____

Total Wind Movement and Average Velocity in Miles per Hour
For Monthly Periods Beginning March 1929
on Guthrie Soil Erosion Experiment Farm.

	1929		1930		1931		1932	
	Total Movement	Average Velocity	Total Movement	Average Velocity	Total Movement	Average Velocity	Total Movement	Average Velocity
	Miles	M/P/H.	Miles	M/P/H.	Miles	M/P/H.	Miles	M/P/H.
January	No Record		8512.8	11.4	5579.5	7.2	6491.3	9.3
February	3364.3	8.3	7334.6	10.9	4831.4	7.4	7175.7	9.6
March	8417.3	11.3	8549.9	11.3	8974.2	12.1	8697.2	11.7
April	9808.1	13.6	8074.3	11.3	6921.4	9.5	7781.8	10.8
May	8009.5	10.7	8103.6	10.8	7928.9	10.7	7495.5	9.7
June	8822.6	12.2	7762.8	10.7	7374.7	10.2	5168.7	7.5
July	6711.9	8.9	7395.5	9.9	4362.9	5.9	6265.7	8.5
August	6969.2	9.3	5932.8	8.0	5868.0	7.9	7304.6	9.7
September	5851.6	8.1	6722.2	9.2	8522.0	11.9	5105.7	6.9
October	5735.1	7.3	6275.4	8.4	7959.0	10.6	6629.1	9.8
November	5879.6	8.4	6706.6	9.3	6307.0	8.4	5050.7	7.0
December	6012.8	8.3	5424.1	7.2	6581.0	8.9	6694.2	8.7
Yearly Total	75582.0		86794.6		81208.0		79[illegible].0	
Monthly Average	6871.0	9.6	7232.8	9.8	6767.3	9.2	6657.5	9.1

TABLE No. 2

Record of Crop Rotations
Red Plains Soil Erosion Experiment Station

Field or Plot Number	1929 Spring	1929 Fall	1930 Spring	1930 Fall	1931 Spring	1931 Fall	1932 Spring	1932 Fall	1933 Spring	1933 Fall	1934 Spring	1934 Fall	1935 Spring	1935 Fall	1936 Spring	1936 Fall	1937 Spring	1937 Fall	1938 Spring	1938 Fall
Field A	Cotton	Rye	Cotton	Rye	Corn	Cowpeas	Oats	Cowpeas	Corn	Cowpeas	Oats	Cowpeas	Cotton	Wheat	Corn	Cowpeas	Oats	Cowpeas	Cotton	Wheat
Field B	Cotton	Cowpeas	Oats	Cowpeas	Cotton	Wheat	Corn	Cowpeas	Oats	Cowpeas	Cotton	Wheat	Corn	Cowpeas	Oats	Cowpeas	Cotton	Wheat	Corn	Cowpeas
Field C	Cotton	Rye	Kaffir	Cowpeas	Oats	Cowpeas	Cotton	Wheat	Corn	Cowpeas	Oats	Cowpeas	Cotton	Wheat	Corn	Cowpeas	Oats	Cowpeas	Cotton	Wheat
Plot C_1	Cotton	Rye	Kaffir	Cowpeas	Oats	Cowpeas	Cotton	Wheat	Corn	Cowpeas	Oats	Cowpeas	Cotton	Wheat	Corn	Cowpeas	Oats	Cowpeas	Cotton	Wheat
Plot G			Cotton	Wheat	Cowpeas		Cotton	Wheat	Cowpeas		Cotton	Wheat	Cowpeas		Cotton		Cowpeas		Cotton	Wheat
Plot G_1			Cotton	Wheat	Cowpeas		Cotton	Wheat	Cowpeas		Cotton	Wheat	Cowpeas		Cotton		Cowpeas		Cotton	Wheat
Plot H			Cotton	Wheat	Corn		Corn		Kaffir		Corn		Kaffir		Corn		Kaffir		Corn	
Plot 13	Cowpeas	Rye	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat
Plot 14	Cowpeas	Rye	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat
Plot 15	Cowpeas	Rye	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat	Cowpeas	Wheat	Cotton	Wheat
Plots 1	to 12 are shown		separately under Sub-project S.:E. 1.9																	

on the fields devoted to engineering experiments. The record of crop rotation is given in Table 2. Discussions of yields and other cropping features are included with the various experiments.

E X P E R I M E N T N O. 1

Terraces with Different Vertical Spacings.

This experiment affords information concerning the proper vertical spacing for terraces located on the particular soil and slope. Terraces 1-A to 6-A, located in Field A in the northwest corner of the farm, (See map, Figure1), are included. Each terrace is 700 feet in length with a uniform grade of four inches per 100 feet. Starting with Terrace 1-A and going up the slope the vertical interval between terraces is as follows: two feet, three and one half feet, five feet, five feet, three and one half feet and two feet. The fact that the various intervals are repeated in reverse order makes possible the elimination of variations due to differences in soil and slope by averaging the results obtained for each pair of terraces with same spacing. The average slope of land is about ~~six~~ 5.5 per cent. The land served as wooded pasture prior to breaking out for experimental use. Data pertaining to the dimensions and drainage areas of these terraces are given in the first six columns of Table 14. Comolete equipment for measuring run-off and soil losses are installed at the end of each terrace.

<u>Run-offand Soil Losses for Year</u>:

RUn-off percentages and soil losses, for the individual

terraces in Field A, by crop seasons and for the total years 1931, and 1932, are given in Tables 13 and 14. Run-off data for 1930 is in Table 12. The per cent of the total rainfall which ran off during the year varied from 18.0 per cent for Terrace 4-A to 27.6 per cent for Terrace 6-A. The tendency toward a higher percentage run-off on the two upper terraces was also present in 1931. This tendency may be due to the upper reaches of the field having been more affected by erosion prior to breaking out for experimental use.

Inspection of the records of percentage run-off for the three years of record shows consistently that this percentage decreases as the vertical spacing between terraces is increased. This fact was particularly noticeable for the year 1932 when the percent of the years rainfall which appeared as run-off was 26.1 per cent for the average of the two terraces with two foot vertical spacing, 23.8 per cent for the three and one ahlf foot spacing, and 18.9 per cent for the five foot spacing. It appears that this variation may be caused by the increased distance down the slope between terraces and therefore increased time for percolation above the terraces of large vertical spacing.

Study of soil loss figures for the years 1931 and 1932 show important difference. Soil losses for the year 1931 were 2.74 tons per acre for the average of thw two terracesfro two foot vertical spacing, 3.96 tons per acre for the three and one half foot spacing and 4.98 tons per acre for the five foot spacing or an average increased loss of about one ton per acre for each additional foot of vertical spacing.

For the year 1932, the soil loss on the average of the two foot spacings was 3.57 tons per acre, 3.37 tons per acre on the 3½ foot spacing, and 3.05 tons per acre on the 5 foot spacing, which indicates a slight decrease in soil loss as the vertical spacing is increased.

The seeming incompatibility of these two years results may be attributed to the great difference in effect on erosion as exerted by clean cultivated row crops and by close growing drilled crops. During 1931 Field A was cropped to corn in contoured rows followed by cowpeas planted in a similar manner. For the year 1932, the field was covered with a well established oat crop during the period May 15th, to July 15th when 39.5 per cent of the year's rainfall occurred, causing 75 per cent of the year's run-off. The row crop of 1931 permitted the water flowing down the slope between terraces to gain velocity as the slope distance increased thus forming small gullies, See Figure 8, which results in increased erosion on the larger spacings. The close root mat of the oat cover existing in 1932 checked the velocity of flow down the slope, forcing the water to filter slowly past the oat plants. This action tended to make the rate of erosion practically constant on all the terraces regardless of vertical spacing. The slight tendency toward a reduction of soil loss per acre with increased vertical spacing may have been caused by the decreased percentage of run-off on the larger intervals as previously discussed. The rains which occurred in 1932 on the ~~ghi~~ highly protective oat crop were frequent, and very intense, while those occurrin in 1931 on the clean cultivated row crop were few in number and not of great intensity. It seems probably, therefore, that the spread between the effectiveness of

these two crops in erosion prevention efficiency would have been greater under comparable conditions of rainfall.

Run-off and Soil Loss by Storms:

In Table 3 are listed measurements of rainfall, run-off and soil losses for principal ~~xxx~~ storms occurring during the year 1932. The storm of May 31st represented the highest sustained rainfall intensities of the year, ranging from 6.00 inches per hour for the five minute intensity to 3.84 inches per hour for the 30 minute intensity. The storm total precipitation was 3.12 inches. The intensities of run-off produced by these rainfall intensities were not excessively high, due to the ground being very dry at the time of the storm and also to the close cover of growing oats. This storm marked the beginning of the series which produced the bulk of the year's rainfall and run-off as previously discussed.

The maximum run-off intensities for the year 1932 were caused by the storm of June 24th (see Figure 9) for hydrographs and rainfall curves with a maximum five minute intensity of 4.60 inches per hour and a 30 minute intensity of 3.76 inches per hour. Due to the ground being saturated by previous rains, the percentage and intensity of run-off were ~~ghi~~ higher than for the rain of May 31st, which was greater in both volume and intensity. The effect of the close oat cover in reducing the percent run-off and soil loss per acre on the terraces of wider spacing is particularly noticeable for these two storms.

The rain of 1.01 inches occurring on October 3rd, produced the highest five minute intensity, 6.32 inches per hour, yet recorded at

TABLE No. 3

Terraces 1-A to 6-A With Different Vertical Spacings
Measurements of Rainfall, Run-off, and Soil Loss For Principal Storms During the Year 1932
Red Plains Soil Erosion Experiment Station Near Guthrie, Oklahoma

Date Of Storm	Average Rates Of Rainfall					Total Rainfall For Storm Period	Maximum Rates Of Run-off												Total Run-off In Per Cent of Total Rainfall						Soil Loss In Tons Per Acre						Remarks (Crops, Soil, Etc)
	5 Min.	10 Min.	15 Min.	20 Min.	30 Min.		1 - A		6 - A		2 - A		5 - A		3 - A		4 - A		1-A	6-A	2-A	5-A	3-A	4-A	1-A	6-A	2-A	5-A	3-A	4-A	
							Sec. Feet	In/Hr	Sec. Feet	In/Hr	Sec. Feet	In/Hr	Sec. Feet	In/Hr	Sec. Feet	In/Hr	Sec. Feet	In/Hr													
January 4	0.48	0.42	0.40	0.36	0.30	2.26	a	a	0.16	0.28	0.16	0.16	0.30	0.32	0.30	0.22	d	d	a	5.0[b]	5.0[b]	5.0[b]	5.0[b]	5.0[b]	a	0.05	0.05	0.07	0.11	0.11	Cutting of corn stalks was com-
" 15	0.36	0.36	0.32	0.30	0.26	0.73	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	pleted November 11, 1931. Field
" 21	0.60	0.60	0.56	0.51	0.44	1.22	0.20	0.34	0.20	0.35	0.32	0.32	0.40	0.43	0.40	0.29	0.35	0.26	67.0	70.7	36.6	77.5	48.0	40.0	a	0.32	0.23	0.57	0.37	0.21	was plowed on February 6, 1932
Feb. 10	1.86	1.60	1.30	1.00	0.80	0.50	a	a	a	a	a	a	a	a	0.01	0.01	a	a	a	a	a	a	3.4	a	a	a	a	a	a	a	with one-way disc plow. Field
May 31	6.00	4.68	4.20	4.35	3.84	3.12	1.27	2.14	1.39	2.46	d	d	d	d	3.52	2.54	2.90	2.15	37.2	51.0	35.0[b]	35.0[b]	39.2	33.5	1.38	0.79	0.78	0.59	0.75	0.61	was disced and drilled to oats on
June 3	0.96	0.84	0.64	0.63	0.52	0.77	a	a	a	a	a	a	0.04	0.05	a	a	a	a	a	a	a	8.9	a	a	a	a	a	a	a	a	February 24, 1932. The crop was
" 4	2.28	1.86	1.68	1.44	1.14	0.97	0.49	0.83	0.54	0.96	0.92	0.93	0.84	0.90	1.15[c]	0.83[c]	0.99	0.73	76.3	88.4	84.5	62.7	50.0	41.4	0.13	0.25	0.29	0.15	0.22	0.13	damaged by winds and lack of rain-
" 5	2.11	1.79	1.77	1.53	1.03	0.74	0.22	0.37	0.37	0.66	0.64	0.64	0.71	0.76	0.92	0.66	0.84	0.62	73.7	62.8	76.8	46.5	37.3	28.4	0.13	0.13	0.13	0.06	0.08	0.04	fall during March. Oats were cut
" 23	1.34	1.15	1.09	1.03	0.97	0.63	d	d	0.09	0.16	0.14	0.14	0.18	0.19	0.07	0.05	d	d	20.0[b]	18.7	37.9	22.6	11.7	20.0[b]	a	a	a	0.01	0.01	a	June 14, 1932. Oat stubble was
" 24	4.60	4.10	4.17	3.88	3.76	3.07	d	d	1.84	3.26	3.29	3.31	3.24	3.48	4.82	3.47	4.00	2.96	80.0[b]	86.0	79.5	85.3	66.0	65.4	1.51	1.17	1.01	0.70	9.95	0.94	plowed under with one-way disc
" 26	0.48	0.36	0.32	0.30	0.28	0.80	0.14	0.24	0.05	0.09	0.12	0.12	0.12	0.13	0.05	0.04	d	d	10.0[b]	10.0[b]	10.0[b]	10.0[b]	10.0[b]	10.0[b]	0.01	0.11	0.01	0.01	0.01	0.01	plow on July 12, 1932. Cowpeas
" 30	1.73	1.09	0.97	0.90	0.72	0.42	0.35	0.59	0.25	0.44	0.64	0.64	0.58	0.62	0.92	0.66	0.71	0.52	92.0	63.8	83.0	74.5	60.7	44.7	0.08	0.04	0.47	0.05	0.05	0.03	were planted in contoured rows on
July 5	4.46	3.18	2.51	2.05	1.36	1.56	1.23	2.05	1,25	2.22	2.26	2.28	2.26	2.43	3.94	2.84	3.18	2.36	75.3	69.0	85.3	67.5	56.6	48.0	0.31	0.25	0.38	0.27	0.33	0.21	July 14, 1932. Green cowpeas were
August 16	2.28	2.22	2.20	1.86	1.38	3.98	0.14	0.24	0.43	0.76	0.25	0.25	0.92	0.99	0.80	0.58	1.15	0.85	25.6	34.3	4.7	31.2	16.5	17.8	0.01	0.30	0.07	0.47	0.21	0.31	plowed under on October 7, 1932
October 3	6.32	4.02	3.05	2.51	1.79	1.01	0.30	0.51	0.74	1.31	0.37	0.37	1.15	1.23	0.77	0.55	0.77	0.56	25.8	41.6	19.8	47.5	33.6	23.2	0.01	0.16	0.10	0.24	0.15	0.10	with moldboard plow.
" 25	3.90	3.47	2.64	2.01	1.36	2.12	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	
[illegible]. 23	0.72	0.54	0.44	0.42	0.38	2.63	d	d	0.12	0.21	0.18	0.18	0.20	0.21	0.14	0.10	0.18	0.13	5.0[b]	5.0[b]	5.0[b]	5.0[b]	5.0[b]	5.0[b]	a	0.01	0.02	0.01	0.06	0.10	

Terrace	Land Slope	Vertical Spacing	Grade	Length
1-A	5.35	2.0	4"/100'	700'
6-A	5.60	2.0	4"/100'	700'
2-A	5.46	3.5	4"/100'	700'
5-A	5.76	3.5	4"/100'	700'
3-A	5.45	5.0	4"/100'	700'
4-A	5.58	5.0	4"/100'	700'

Note:
a = No run-off or no soil loss
b = Total run-off estimated
c = Maximum rate of run-off estimated
d = No record due to instrument failure

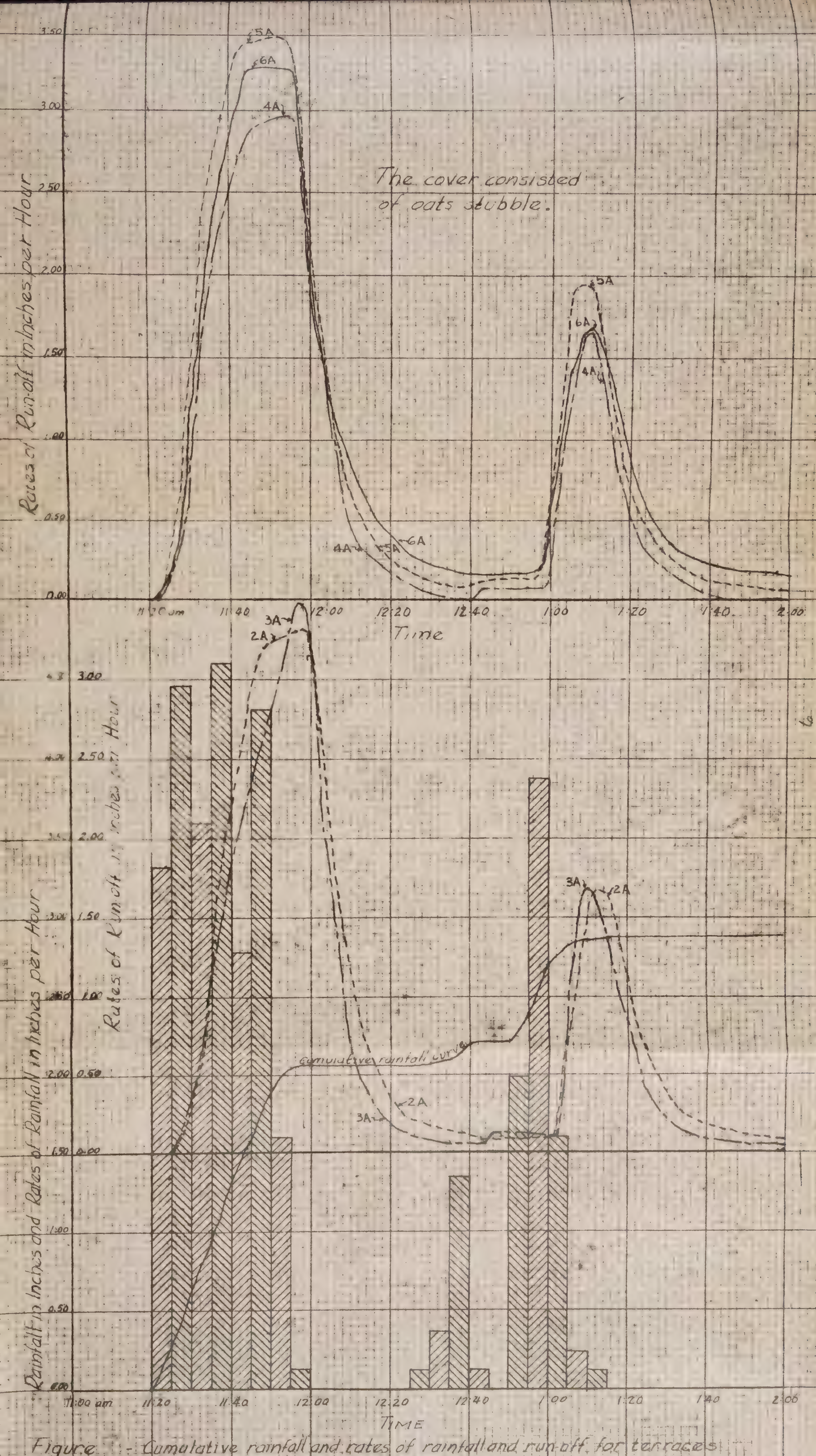


Figure - Cumulative rainfall and rates of rainfall and run-off for terraces 700' long, with a grade of 4" per 100', and different vertical spacings as follow - 1A and 6A = 2 feet, 2A and 5A = 3.5 feet, 3A and 4A = 5 feet. Rain of June 24, 1932.

this station. The intensities for longer periods were not excessive, (Rainfall intensity and accumulation, and rates of run-off are shown graphically in Figure 10). Percentage and intensity of run-off and amount of soil loss per acre were not excessive due to the dry and absorptive condition of the soil. During this storm the field was supportinga clean cultivated row crop of cowpeas and as a result was subject to the formation of small gullies which increased in size as the vertical spacing between terraces increased. This resulted in increased soil loss per acre as the vertical spacing between terraces was increased, which duplicatedn the results obtained during the storms of 1931, when the field was cropped in a similar manner.

Crop Yields:

A crop history of the field for the year 1932 is given in Table 3 and crop yields for the years 1931 and 1932 in Tables 13 and 14. The corn yields for 1931 were very low because the corn crop was practically destroyed by hot winds at tassle stage. In 1932 throat crop was damaged by wind cutting but could not be considered a total loss. The corn yield per acre in 1931 averaged 6.9 bushels per acre on the disturbed area, that is, the terrace ridge and channel, and 5.3 bushels per acre on the interval or area not disturbed by the terracing operation. Field harvesting for 1932 did not divide the oat crop according to disturbed and not disturbed areas, but sample strips harvested perpendicular to the contour by the Bureau of Chemistry and Soils indicated a greater yield on the disturbed areas.

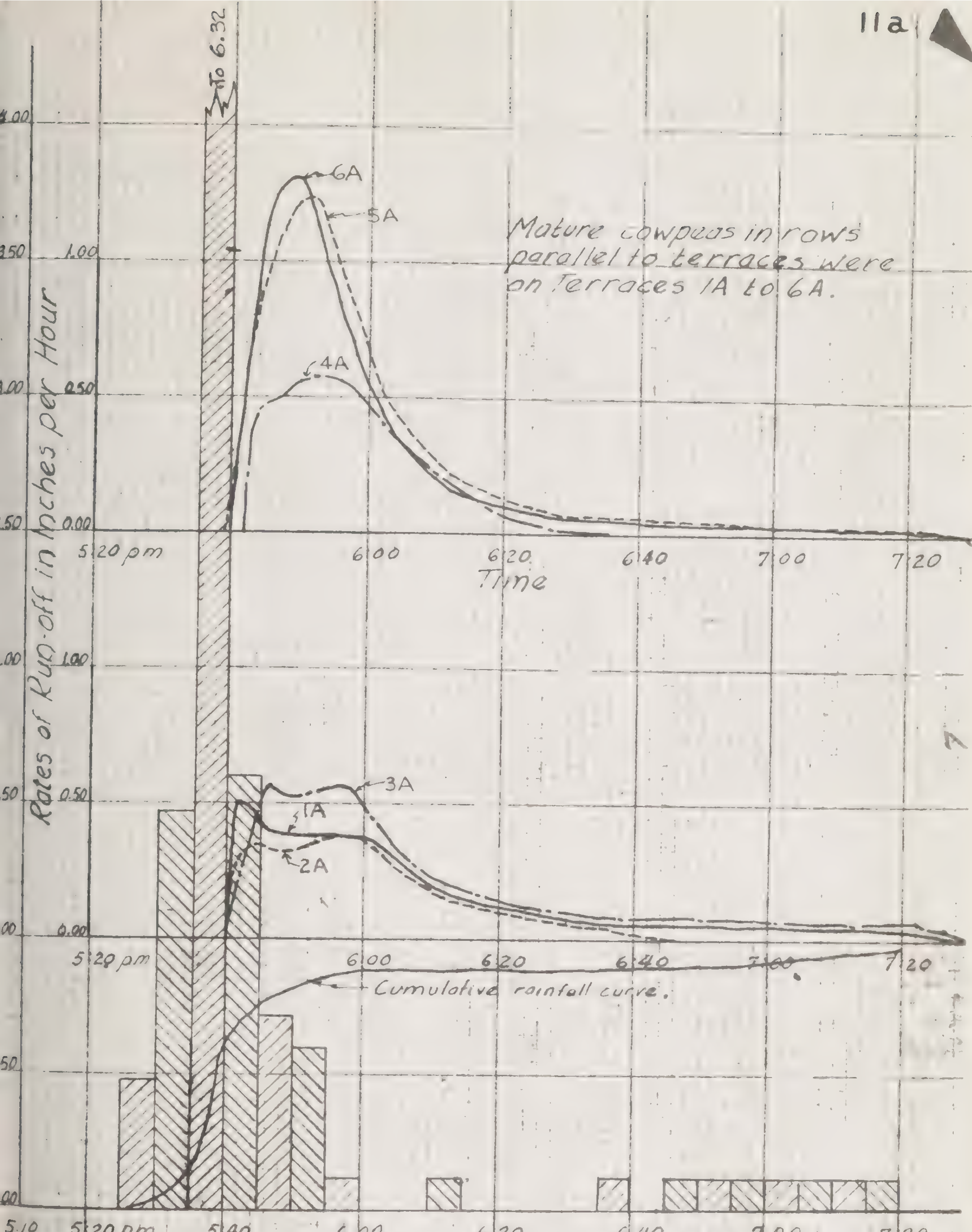


Figure 11 - Cumulative rainfall and rates of rainfall and runoff for terraces 700' long, with a grade of 4" per 100', and different vertical spacings as follows: 1A and 6A = 2 feet, 2A and 5A = 3.5 feet, 3A and 4A = 5 feet. Rain of Oct. 3, 1932

Conclusions:

It is not desirable to base definite conclusions upon the data now available on this experiment. The following trends have been well outlined, however:

1. The percent of the rainfall which appears as run-off decreases as the vertical spacing between terraces increases, due to the increased opportunity for percolation.

2. Soil loss in tons per acre increases directly with the vertical spacing between terraces when the ground is bare, is fallow, or cropped to clean cultivated row crops.

3. When the field is cropped to close growing drilled crops, such as oats, the soil loss is not greatly influenced by the vertical spacing.

EXPERIMENT No. 3

Terraces With Different Grades

Description and Object:

The object of this experiment is to determine the effect of the terrace grade on conservation of soil and moisture. This data will indicate the most efficient grade for use in laying out terraces on the particular soil and slope.

Terraces 3-C to 6-C, each 1,500 feet in length and with respective grades of six, four, two and zero inches per 100 feet, comprise the layout for this experiment. They are located on the northeastern slope of the farm. The vertical spacing of 3-C is constant at $3\frac{1}{4}$ feet while that of each of the other three terraces varies from about $4\frac{1}{4}$ feet at the upper end to two feet at the lower end or an average of approximately $3\frac{1}{2}$ feet. The land traversed by the lower five to six hundred feet of each terrace has been in cultivation for many years with some erosion as a result. The remaining portion of the terraces lies on virgin land that was used for pasture prior to experimental use. Data pertaining to dimensions and drainage areas of terraces are given in the first six columns of Table 14. Complete run-off and silt measuring units are installed at the outlet of each terrace.

Run-off and Soil Loss for the Year:

Run-off percentages and soil losses on these terraces for crop seasons and the total year are shown in Table 13 for the year 1931 and Table 14 for the year 1932.

The run-off for the year 1932, in per cent of the total rainfall varied from 23.3 per cent for level Terrace 6-C to 26.5 per cent for Terrace 4-C with grade of 4 inches per 100 feet. Terrace 3-C with a grade of 6 inches per 100 feet had a lower per cent run-off than 4-C and in 1931 was lower than all but 6-C. Inspection of the map, Figure 1, shows that the drainage area of Terrace 3-C, is narrower at the upper end than the other terraces and that the middle third is much wider due to a decrease in land slope. This concentration of area on a flatter slope would allow the run-off water more time to percolate into the soil before entering the terrace channel and consequently might reduce the per cent run-off.

The per cent run-off on level Terrace 6-C has consistently been less than on the other three terraces in the experiment. This is due, first, to the decreased velocity of flow in the terrace channel with consequent greater opportunity for percolation into the soil and, second, to the pondage effect created by small deltas in the terrace channel, (see Figurell). These deltas are formed at points of concentrated flow down the interterraced area, (See Figure 12) and are not removed from the channel of the level terrace by the flowing water because of its low velocity.

The effect of these deltas from year to year on the grade of the terrace channels is shwon in Figure 13 which gives original profiles of the terrace ridges and channels as run originally in 1929, and as run early in 1933. In Terraces 3-C and4-C which have the steeper grades and therefore the greatest velocities of flow the present channel grade, as

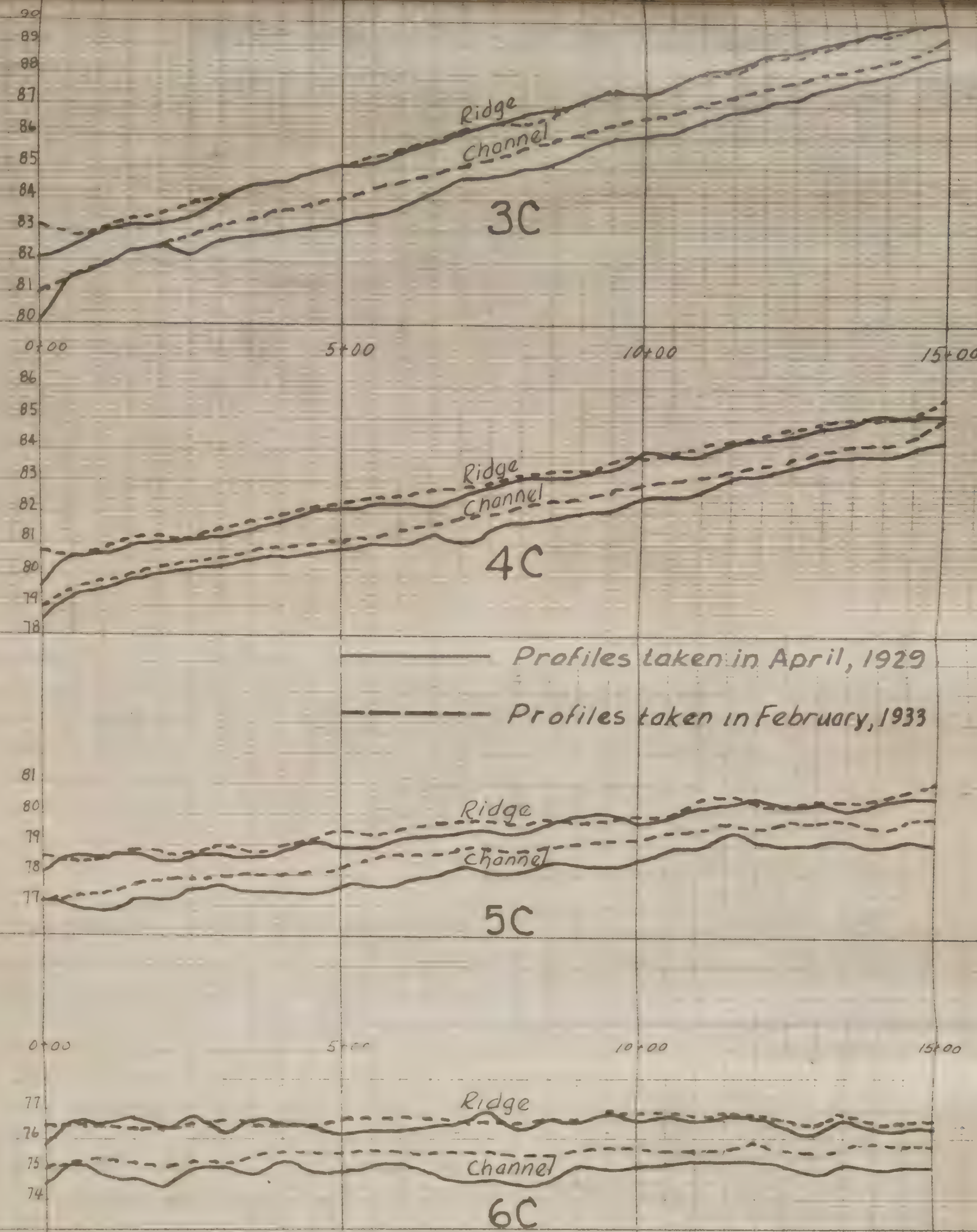


FIGURE – TERRACE PROFILES, FIELD C
RED PLAINS SOIL EROSION EXPERIMENT STATION

Figure 11: Deposit of silt in channel of Terrace 6-B,
July 7, 1932

Figure 12: Gullies between Terraces 2-C and 3-C caused by concentration of water from contoured rows to natural depression. June 8, 1932.

indicated by the lower dotted line, is practically perfect. In Terrace 5-C irregularities occur at points which field observations show to coincide with delta points and in Terrace 6-C this effect is much more pronounced.

The lower portions of the channels of Terraces 3-C and 4-C with grades of 6 inches and 4 inches per 100 feet, are subject to a scouring effect, see Figure 14. This scouring rapidly removes all deltas from the channel and would soon cut a ditch were the outlet not protected.

Data relating to soil loss on these terraces indicate that this loss increases directly with the grade of the terrace. In 1931 (See Table 13) the loss varied from 1.25 tons per acre on level Terrace 6-C to 5.46 tons per acre on Terrace 3-C with grade of 6 inches per 100 feet. For 1932 this loss increased to 4.06 tons per acre on the level terrace and 15.06 tons per acre on Terrace 3-C.

For the two years of record, Terrace 3-C with a grade of 6 inches per 100 feet, has lost 3.9 times as much soil per acre as level Terrace 6-C, Terrace 4-C with grade of 4 inches per 100 feet has lost 2.0 times as much soil, and Terrace 3-C with grade of 2 inches per 100 feet has lost 1.7 times as much soil as Terrace 6-C. Investigations late in 1932 showed that the lower 500 feet of Terrace 5-C had cut out until the grade was greater than the desired 2 inches per 100 feet. This was carefully corrected and it is believed that as a result the ratio of soil loss between 5-C and 6-C will be considerably lower during the year 1933. Inequalities in the grade of the other three terraces were also corrected so that recordsin 1933 will be subject to no error from this source.

Figure 14: Erosion in channel of 3-[illegible], 50 feet from outlet. Terrace is 1,500 feet long with a constant grade of 6"/100'. June 8, 1932

The great increase of soil loss and run-off on these terraces during the year 1932 as compared with 1931 may be expàained, first, by the succession of intense rains occuring during the summer of 1932 on saturated ground as compared with scattered small rains during 1931. A second important reason lies in the different in cover between the two years. A close cover of oats on the field during the spring rain period of 1931 resulted in a minimum intensity of run-off and soil loss. Before the fall rains of 1931 the field has been plowed with a moldboard plow and therefore was able to absorb a great deal of moisture.

Cotton in contoured rows was on the field during the intense rains of 1932 giving the ground but little protection.

Run-off and Soil Loss by Storms, 1932:

Measurements of rainfall, run-off, and soil loss on the terraces comprising this experiment are listed in Table 4 for the seventeen storms which occurred during the year 1932. Values of intensity, amount, and duration for the rain of June 24th fall slightly under those for the rain of May 31st, but are very similar. The rain of June 24th, however, fell on saturated soil, whereas the rain of May 31st fell on dry soil. This caused much greater intensities of run-off, percentages of rainfal appearing as run-off, and soil loss for the rain of June 24th. (See Figure 15 for a graphical record of rainfall and run-off for the rain of June 24th). It is interesting to note that for either of the above mentioned rains the soil loss in tons per acre is practically equal to the total for the year 1931.

TABLE No. 4

Terraces 3-C to 6-C With Different Grades
Measurements of Rainfall, Run-off, and Soil Loss For Principal Storms During the Year 1932
Red Plains Soil Erosion Experiment Station Near Guthrie, Oklahoma

Date Of Storm	Average Rates of Rainfall 5 Min.	10 Min.	15 Min.	20 Min.	30 Min.	Total Rainfall For Storm Period	Maximum Rates Of Run-off: 3-C Sec. Feet	3-C In/Hr.	4-C Sec. Feet	4-C In/Hr.	5-C Sec. Feet	5-C In/Hr	6-C Sec. Feet	6-C In/Hr.	Total Run-off In Per Cent of Total Rainfall 3-C	4-C	5-C	6-C	Soil Loss In Tons Per Acre 3-C	4-C	5-C	6-C	Remarks Crop, Soil, Etc.
January 4	0.48	0.48	0.44	0.39	0.34	2.35	0.56	0.19	0.71	0.25	a	a	a	a	22.6	21.7	a	a	0.21	0.25	a	a	Cowpeas were plowed
" 15	0.36	0.30	0.28	0.27	0.28	0.74	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	under for green
" 21	0.72	0.60	0.56	0.51	0.42	1.19	0.77	0.27	0.82	0.29	0.04	0.002	0.10	0.05	61.3	48.0	20.0[b]	21.8	0.43	0.39	0.09	Trace	mannre with tandem
Feb. 10	2.16	1.80	1.40	1.17	0.88	0.50	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	disc, November 10,
May 31	6.00	4.68	4.20	4.35	3.84	2.96	d	d	6.80	2.44	5.41	2.08	1.98	0.95	41.7	46.6	56.4	48.3	3.13	2.28	2.34	1.11	1931. Field was
June 3	0.96	0.84	0.64	0.63	0.52	0.81	0.22	0.08	0.22	0.08	0.18	0.07	0.12	0.06	16.0[b]	10.0[b]	29.6	5.0[b]	0.14	0.06	0.24	0.04	plowed with mold-
" 4	2.28	1.86	1.68	1.44	1.14	1.09	3.53	1.23	3.62	1.30	2.85	1.10	1.23	0.59	69.7	76.0	75.0	88.0	1.35	0.82	0.52	0.39	board plow, February
" 5	1.92	1.68	1.64	1.44	0.98	0.73	2.48	0.86	2.82	1.01	1.57	0.61	0.51	0.25	59.7	59.5	60.5	68.5	0.84	0.48	0.32	0.13	8, 1932. Cotton was
" 23	1.92	1.56	1.44	1.38	1.32	0.90	0.15	0.05	a	a	a	a	a	a	4.1	a	a	a	a	a	a	a	planted in contoured
" 24	4.80	3.84	3.60	3.54	3.24	2.84	7.51	2.62	6.92	2.48	5.28	2.03	2.33	1.18	71.5	75.0	73.0	79.0	4.72	2.49	2.58	1.52	rows, May 6, 1932.
" 26	0.48	0.36	0.32	0.30	0.28	0.83	0.28	0.10	0.25	0.09	0.10	0.04	d	d	36.3[b]	20.5	32.0	20.0[b]	0.29	0.09	0.13	Trace	First cultivation on
" 30	1.56	1.02	0.84	0.84	0.72	0.42	1.93	0.67	1.72	0.62	0.99	0.38	0.40	0.19	60.7	59.5	52.8	61.8	0.59	0.21	0.12	0.06	May 31, 1932. Pick-
July 5	4.56	3.72	2.88	2.34	1.64	1.76	9.27	3.23	7.27	2.60	4.70	1.81	1.88	0.91	68.0	67.0	64.0	74.0	2.19	1.40	0.68	0.56	ing of cotton com-
August 16	2.88	2.64	2.24	1.92	1.52	3.76	0.41	0.14	0.41	0.15	0.43	0.16	d	d	12.3	16.4	12.2	10.0[b]	0.55	0.16	0.11	0.21	pleted on October
October 3	5.64	3.72	2.96	2.40	1.70	1.02	2.24	0.78	2.24	0.80	d	d	0.27	0.13	32.1	37.4	24.2[b]	13.7	0.21	0.15	0.07	0.02	14, 1932. Winter
" 25	4.56	3.84	2.88	2.25	1.52	2.14	0.33	0.11	0.25	0.09	0.11	0.04	a	a	3.8[b]	4.0[b]	3.8[b]	a	0.04	0.01	0.01	a	wheat drilled bet- ween
Dec. 23	0.72	0.60	0.44	0.42	0.38	2.78	0.33	0.11	0.33	0.12	0.18	0.07	0.18	0.09	25.0[b]	25.0[b]	25.0[b]	25.0[b]	0.17	0.03	0.06	0.02	ween cotton rows on
																							October 13, 1932.

Terrace	Land Slope	Vertical Spacing	Length	Grade
3-C	4.33	3.51	1500	6" per 100'
4-C	4.41	3.47	1500	4" per 100'
5-C	4.72	3.43	1500	2" per 100'
6-C	5.51	3.27	1500	Level

Note:
- a. = No run-off or no soil loss
- b. = Total run-off estimated
- d. = No record due to instrument failure

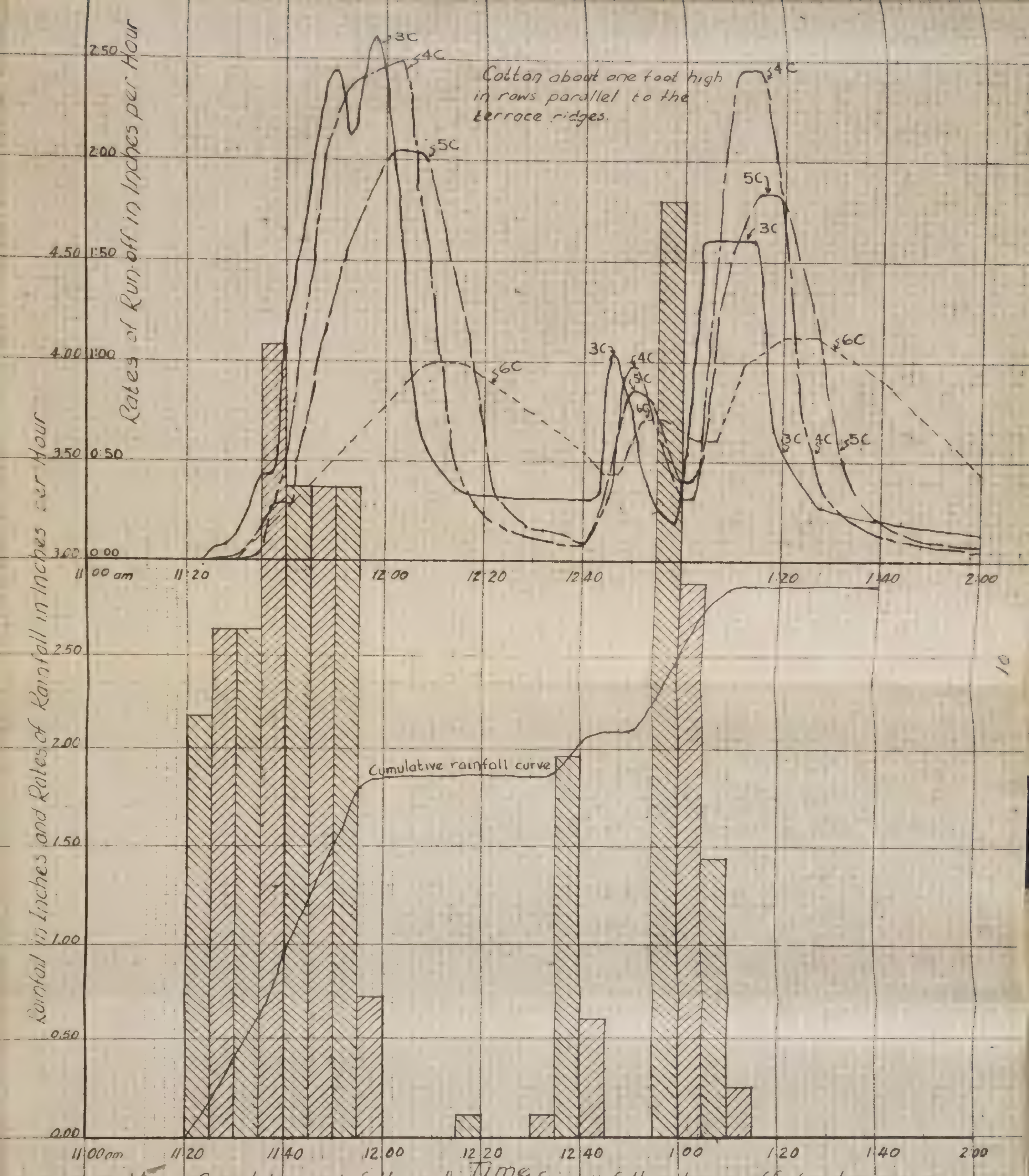


Figure 15 — Cumulative rainfall and rates of rainfall and run-off for terraces 1500 feet long with vertical spacings of approximately 3.5 feet and grades as follow:- 3C = 6" per 100', 4C = 4" per 100', 5C = 2" per 100', and 6C = level. Rain of June 24, 1932.

Hydrograph records of rainfall and run-off for the rain of October 3rd are shown in Figure 16. This rain was very intense and brief, and fell on dry soil.

Comparison of the various rains for the year 1932 substantiates the following trends outlined in 1931.

1. For similar rains the intensity and run-off percentage increase with the degree of saturation of the soil prior to the rain.

2. Per cent rainfall appearing as run-off decreases as the grade of the terrace is decreased, but the variation is small.

3. Intensity of run-off decreases as the grade of the terrace is decreased.

4. Soil loss per acre decreases as the grade of the terrace is reduced.

Crop Yields:

A crop history of the field for the year 1932 is given in Table 4 and crop yields for the years 1931 and 1932 in Tables 13 and 14. The yield records for both years show minimum yields for Terraces 3-C and 6-C with the maximum and minimum grades of the experiment. The low yield from 3-C is probably caused by the scouring effect of the high velocities of flow on the 6 inches per 100 feet grade while the low yield from Terrace 6-C is believed to be due to the ponds caused by the small deltas formed in the terrace channel. These ponds remain for sufficient

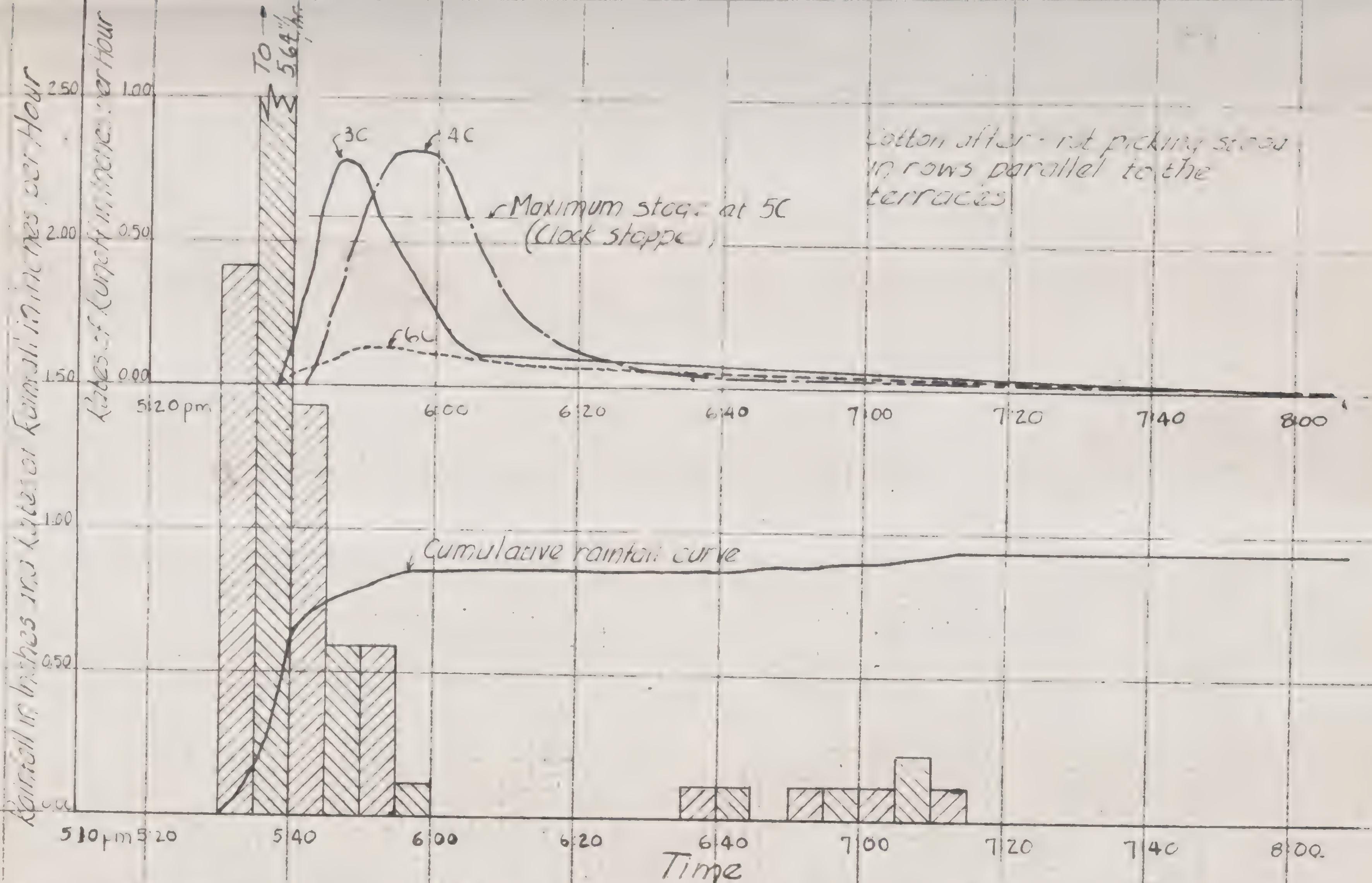


Figure 16 - Cumulative rainfall and rates of rainfall and run-off for terraces 1500 feet long with vertical spacings of approximately 3.5 feet and grades as follow:- 3C = 6" per 100', 4C = 4" per 100', 5C = 2" per 100', and 6C = level. Rain of Oct. 3, 1933.

time to drown part of the crop.

Oat yields for the year 1931 were not determined separately by field measurement for the terrace ridge, channel, and interval but were estimated on the basis of narrow strips harvested perpendicular to the contour by the Bureau of Chemistry and Soils. This estimate indicated a slightly higher yield for the interval than for the disturbed area. For the cotton crop harvested in 1932, each unit of ridge, channel and interval was harvested separately. The average of all four disturbed areas, consisting in each case of the terrace ridge and channel was 684.17 pounds of seed cotton per acre and the average of the total area was 583.07 pounds of seed cotton per acre. The average of the per acre yields of the graded terrace channels was 582.36 pounds of seed cotton as compared with 343.02 pounds of seed cotton per acre in the channel of the level terrace.

Conclusions:

Data secured during the year 1932 substantiates all claims made in 1931 and outlines some new trends. All trends so far established by this experiment are outlined below:

1. The per cent of the rainfall appearing as run-off decreases to a small extent with the grade of the terrace.

2. The intensity of run-off decreases decidedly with decreased grade of terrace.

3. Yearly soil loss per acre is about one fourth as much on the level terrace as on the terrace of six inch grade per 100 feet.

4. The terraces with four and six inch grades appear to retain the desired grade in excellent manner so long as the outlet is protected from scouring, while the two inch and level grades are subject to irregularities produced by channel deltas.

5. Crop yield is lowered on the terrace with six inch grade by securing and is lowered on the level terrace by drowning.

TABLE No. 5

Long Terraces 1-C, 2-C, 2-B, 3-B, and 4-B, With Different Grades, on Virgin and Eroded Land
Measurements of Rainfall, Run-off, and Soil Loss For Principal Storms During the Year 1932
Red Plains Soil Erosion Experiment Station Near Guthrie, Oklahoma

Date Of Storm	Average Rates of Rainfall: 5 Min.	10 Min.	15 Min.	20 Min.	30 Min.	Total Rainfall For Storm Period	Maximum Rates of Run-off: 2-C Sec. Feet	2-C In/Hr.	1-C Sec. Feet	1-C In/Hr.	2-B Sec. Feet	2-B In/Hr.	3-B Sec. Feet	3-B In/Hr.	4-B Sec. Feet	4-B In/Hr.	Total Run-off In Per Cent Of Total Rainfall: 2-C	1-C	2-B	3-B	4-B	Soil Loss In Tons Per Acre: 2-C	1-C	2-B	3-B
January 4	0.48	0.48	0.44	0.39	0.34	2.35	0.46	0.10	0.66	0.11	1.50	0.25	1.37	0.24	d	d	11.5	9.5	37.4	41.8	d	e	0.07	0.14	0.19
" 15	0.36	0.30	0.28	0.27	0.28	0.74	a	a	a	a	0.41	0.07	0.29	0.05	d	d	a	10.0[b]	23.5	11.1	d	e	0.01	0.04	0.02
" 21	0.72	0.60	0.56	0.51	0.42	1.19	0.77	0.17	1.11	0.18	2.16	0.36	1.79	0.31	d	d	36.1	32.5	57.3	59.0	d	e	0.17	0.29	0.32
Feb. 10	2.16	1.80	1.40	1.17	0.88	0.50	0.08	0.02	0.10	0.02	0.37	0.06	1.05	0.18	0.37	0.06	1.3	1.5	8.8	12.8	8.2	e	a	0.03	0.04
May 31	6.00	4.68	4.20	4.35	3.84	2.96	8.00	1.81	8.00[c]	1.29[c]	11.87[c]	1.95[c]	12.01	2.12	8.00[c]	1.41[c]	36.0	32.2	37.7	46.1	44.4	1.71	1.27	1.79	2.02
June 3	0.96	0.84	0.64	0.63	0.52	0.81	0.15	0.03	0.22	0.03	0.71	0.12	0.77	0.13	0.51	0.09	2.6	2.0[b]	21.1	27.2	38.7	0.01	0.04	0.14	0.26
" 4	2.28	1.86	1.68	1.44	1.14	1.09	3.17	0.72	4.70	0.76	6.92[c]	1.14[c]	6.11	1.07	4.60	0.81	40.8	56.7	69.3	67.4	78.6	0.41	0.71	1.44	0.88
" 5	1.92	1.68	1.64	1.44	0.98	0.73	2.57	0.58	2.73	0.44	3.17[c]	0.52[c]	4.60	0.80	2.57	0.45	39.8	32.0	37.0	45.6	52.8	0.21	0.31	0.39	0.37
" 23	1.92	1.56	1.44	1.38	1.32	0.90	a	a	a	a	1.37	0.23	0.37	0.06	a	a	a	a	11.0	6.0	a	a	a	0.13	0.09
" 24	4.80	3.84	3.60	3.54	3.24	2.84	8.88	2.01	13.18	2.12	14.85	2.45	14.69	2.57	10.61	1.87	60.0	62.0	75.4	67.0	74.6	2.29	2.71	3.31	2.74
" 26	0.48	0.36	0.32	0.30	0.28	0.83	0.07	0.02	0.33	0.05	0.88	0.14	0.71	0.12	0.77	0.13	3.4	16.4	36.7	31.6	42.3	0.05	0.09	0.26	0.23
" 30	1.56	1.02	0.84	0.84	0.72	0.42	1.57	0.35	1.79	0.29	3.44	0.57	3.35	0.58	1.93	0.34	26.5	39.2	64.5	55.2	71.2	0.14	0.16	0.27	0.28
July 5	4.56	3.72	2.88	2.34	1.64	1.76	7.27	1.64	10.61	1.71	12.42	2.05	12.20	2.14	8.50	1.50	45.2	51.7	62.0	58.0	65.0[b]	0.70	0.68	1.41	1.87
August 16	2.88	2.64	2.24	1.92	1.52	3.76	2.09	0.47	2.48	0.40	6.80	1.12	6.92	1.21	3.17	0.56	20.0[b]	20.6	34.8	44.3	36.5	0.29	0.29	0.44	0.78
October 5	5.64	3.72	2.96	2.40	1.70	1.02	d	d	1.50	0.24	6.68[c]	1.10[c]	6.22	1.09	1.18	0.21	20.0[b]	24.2	48.1	46.3	13.7	0.08	0.07	0.15	0.24
" 25	4.56	3.84	2.88	2.25	1.52	2.14	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
Dec. 23	0.72	0.60	0.44	0.42	0.38	2.78	0.35	0.08	0.29	0.05	0.57	0.09	0.58	0.10	0.34	0.06	10.0[b]	10.0[b]	15.0[b]	15.0[b]	15.0[b]	0.05	0.07	0.09	0.23

Remarks (Crops, Soil, Etc.)

A cover crop of winter wheat was planted between the rows of cotton stalks in September 1931. The field remained with this cover until April 10, 1932 when it was plowed with a moldboard plow. The whole area was tandem disced and planted to corn on April 25, 1932. Beginning May 10, 1932 the corn was cultivated every two weeks until June 17, 1932. Cowpeas were planted between the corn rows July 26th. Husking of corn was completed August 22, 1932. Corn stalks were plowed under with moldboard plow, October 20, 1932.

Terrace	Land Slope	Vertical Spacing	Grade	Length
2-C	3.66	2.93	0" to 6" per 100'	2525
1-C	3.54	3.91	0" to 4" per 100'	2350
2-B	2.79	3.99	0" to 4" per 100'	2536
3-B	3.70	3.45	0" to 6" per 100'	2856
4-B	4.21	3.98	3" per 100'	2885

Note:
a = No run-off or no soil loss
b = Total run-off estimated
c = Maximum rate of run-off estimated
d = No record due to instrument failure
e = Silt sampling unit not installed

grade, on badly eroded land was slightly less than twice that occurring on similar terrace 1-C on virgin land. During 1932, terrace 3-B with 0" to 6"/100' grade, on eroded land lost 1.5 times as much water as similar terrace 2-C on virgin land. The increase in per cent run-off for the year 1932 as compared to the year 1931 is due largely to the greater intensity and frequency of storms. On both the virgin and eroded land the terraces with variable grade from 0" to 6"/100' lost about three pre cent more of the year's rainfall for 1932 than was true of the terraces with 0" to 4"/100' grade.

Study of soil loss totals shows that for the year 1931 the soil loss in tons per acre for terrace 2-B with a variable grade of 0" to 4"/100' on badly eroded land was 4.67 tons per acre, or 2.4 times the figure of 1.95 tons per acre for similar terrace 1-C on virgin land. For the year 1932, terrace 2-B lost 10.32 tons of soil per acre as compared to 6.65 tons per acre on terrace 1-C. Terrace 2-B lost 1.75 times as much soil as terrace 1-C over the two years of record.

Terrace 3-B, with a variable grade of 0" to 6"/100', lost 5.27 tons of soil per acre in 1931 and 10.56 tons per acre in 1932. These losses are only slightly higher than those on terrace 2-B with)" to 4"/100' grade. A silt sampling device was not installed on terrace 2-C, which has 0" to 6"/100' grade on virgin land, until late in the spring of 1932 and consequently yearly total losses for 3-B and 2-C cannot be compared. However, for the period May 1st, to October 15th, 1932, the soil loss on terrace 2-C was 5.89 tons per acre as compared with 9.76 tons of soil per acre on terrace 3-B, or 1.65 times as much loss from the eroded land as from the virgin.

Run-off and Soil Loss by Storms, 1932:

Measurements of rainfall, run-off, and soil loss on the terraces comprising this experiment are listed in Table 5, for the seventeen storms which occurred during the year 1932.

The rains of May 31st and June 24th, 1932, had the highest rainfall intensities of the year, and produced the largest soil losses in tons per acre. The rain of June 24th was slightly the lower in all values of intensity and volume, was very similar in manner of occurrence. The rain of May 31st occurred on very dry soil while that of June 24th, occurred on soil nearly saturated; consequently, the intensities of run-off were higher for the later rain. Graphical records of rainfall and run-off are shown in Figure 17, for June 24, 1932.

The difference in amount of soil and water loss between the virgin and eroded land was small for each of these storms. Study of the smaller storms which occurred during the remainder of the year shows the terraces on eroded land consistently losing twice as much soil as those on virgin land. This data indicates that the virgin soil can absorb moisture with sufficient rapidity to prevent excessive run-off during all ordinary rains, but that during rains of excessive intensity and duration this absorption does act quickly enough to prohibit run-off.

The rain of October 3rd was very intense for a short period, and produced about one third the volume of the major storms. The maximum intensity did not continue for a time equal to the time of concentration and as a result great intensities of run-off were not attained. The difference in run-off and soil loss between virgin and eroded land is

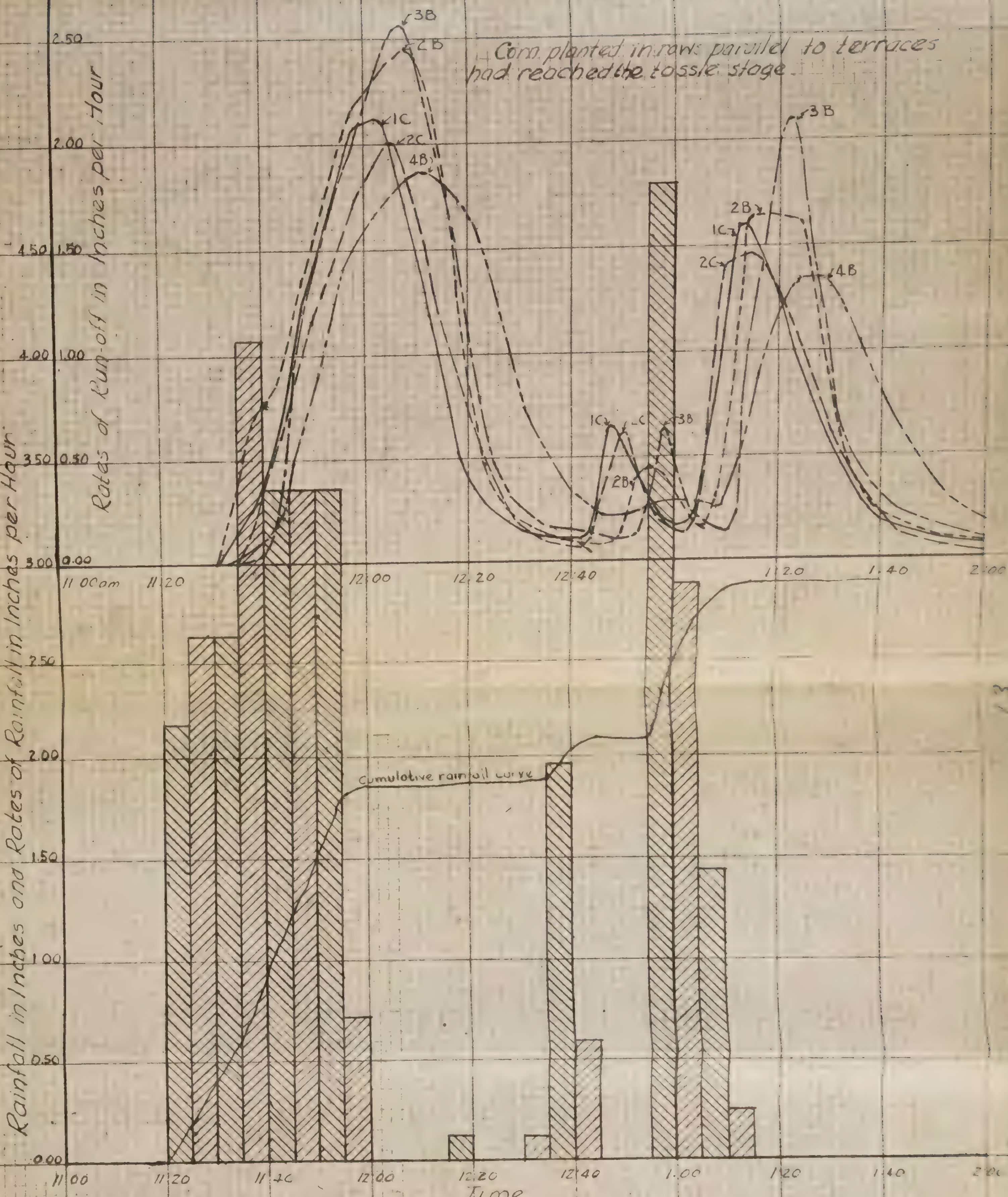


Figure 17 - Cumulative rainfall and rates of rainfall and run-off for terraces one half mile long with average vertical spacings of 3.9 feet. Grades and soil are as follows:- 2C = 0" to 6" per 100 ft., 1C = 0" to 4" per 100 ft., both on virgin soil; 2B = 0" to 6" per 100 ft., 3B = 0" to 4" per 100 ft., and 4B = 3" per 100 ft., all three on eroded soil. Rain of June 24, 1932.

particularly noticeable for this storm. See Figure 18 for hydrographs and rainfall graphs.

<u>Crop Yields:</u>

A crop history of the field for the year 1932 is given ~~xx~~ in Table 5, and crop yields for the years 1931 and 1932 in Tables 13 and 14.

The field produced cotton as a cash crop for the year 1931. Terrace 1-C on virgin land produced 211 pounds of lint cotton per acre as compared with 161 pounds per acre from terrace 2-B, and 135 pounds per acre from Terrace 3-B, both on eroded land. Corn was raised in 1932, but was seriously damaged by chinch bugs and hot winds. The yields on terraces 2-B and 3-B on eroded land were 6.1 and 6.2 bushels per acre respectively. The virgin land produced 31% more cash crop than the eroded land in 1931, and about 150% more in 1932.

During 1931 the average yield of seed cotton per acre on the area composed of the terrace ridge and channel, which was distributed by the terracing operation, for terraces 2-B, 3-B and 4-B, was 537 pounds per acre and the average for the total area was 555 pounds per acre. On terraces 1-C and 2-C the disturbed area yield was 695 pounds per acre and the yield on the total area was 725 pounds per acre. For 1932, the average yield of corn on the disturbed areas of terraces 2-B, 3-B, and 4-B, was 8.57 bushels per acre, and the yield of the total area traversed by the three terraces was 8.05 bushels per acre. The yield of the disturbed areas of terraces 1-C and 2-C was 18.69 bushels per acre for 1932, and the yield of the total area of these terraces was 16.0 bushels per acre. This data indicates that for 1931, the area not disturbed by terracing had but slight advantage over

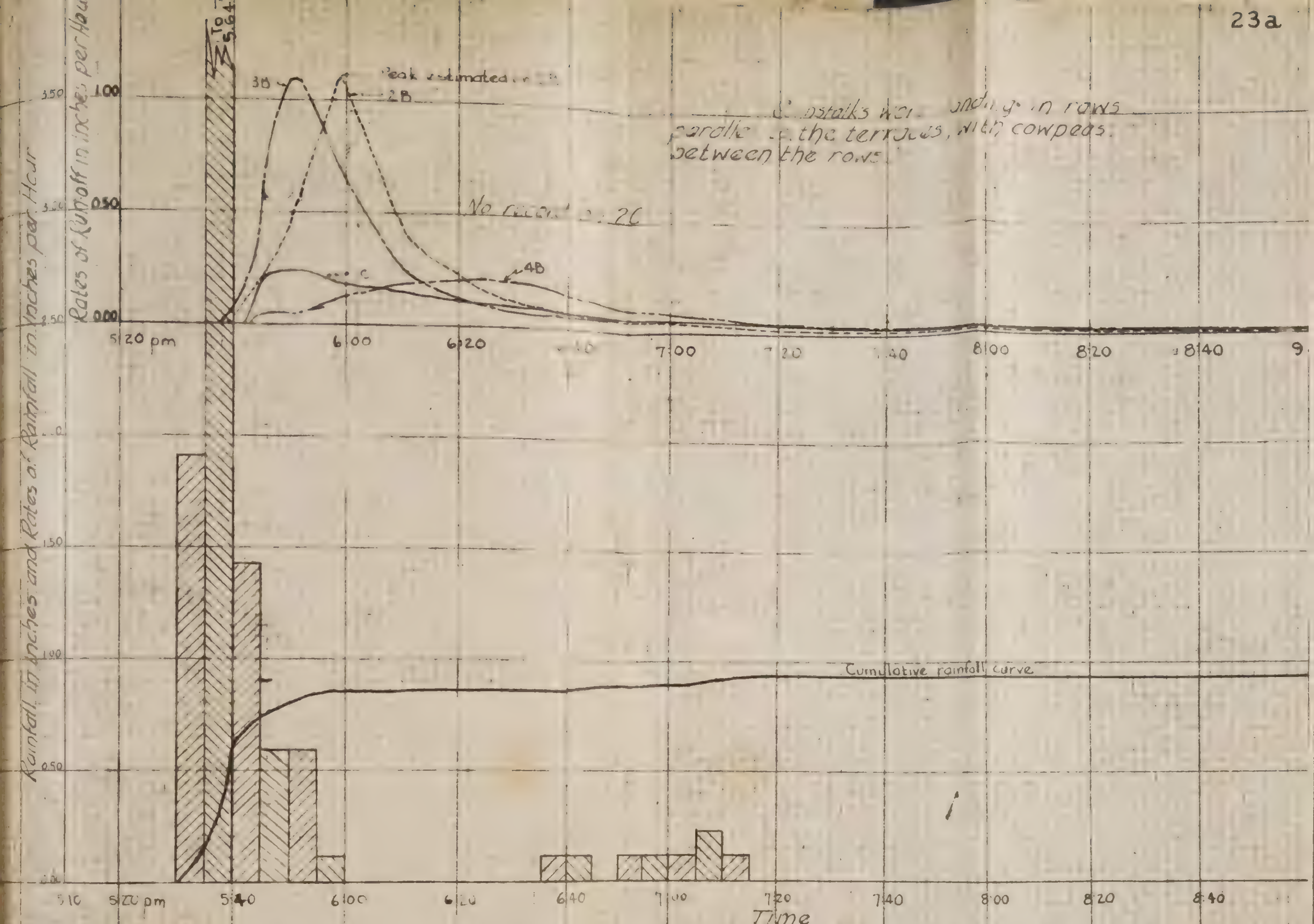


Figure 18 – Cumulative rainfall and rates of rainfall and run-off for terraces one-half mile long, with average vertical spacing of 3.9 feet. Grades and soil are as follows: 2C = 0" to 6" per 100 ft., 1C = 0" to 4" per 100 ft., both on virgin soil; 2B – 0" to 6" per 100 ft., 3B – 0" to 4" per 100 ft., and 4B – 3" per 100 ft., all on eroded soil. Rain of October 3, 1932.

the distrubed area, and in 1932, the disturbed areas of channel and ridge were more productive. This increase may be due to the washing of good soil from the interval or area not disturbed into the terrace channel where it is held and becomes productive. The data seems to indicate that after one or two years service, there is no loss of productivity as a result of soil disturbance by the terracing operation.

Conclusions:

Data secured to date has outlined the following trends which, however, are not yet considered as definite conclusions:

1. Run-off in per cent of yearly rainfall is about twice as large from terraces located on the severely eroded land contained in t is experiment as from the terraces on new land.

2. Yearly soil loss from the terraces on eroded land is approximately twice that from the terraces on new land.

3. During severe storms the absorption capacity of the new soil is overtaxed and the variation between soil loss and run-off on eroded and virgin land is not equal to the yearly average. For lesser storms, the new soil is able to absorb the moisture at a rapid rate and the variation between eroded and virgin land often exceeds the yearly average.

4. Terraces of one half mile length create excessive discharge and consequently extreme depths of flow in the lower sections of the terrace channel. As a result terraces must at all times be maintained to heights of about 18 inches for the

lower 500 feet of length.

5. Crop yields from the terraces located on the virgin land of this experiment were from 31 to 150 per cent higher than those from the terraces on eroded land.

6. Reduction of crop productivity on the soil disturbed by the terracing operation practically disappears after the first two or three years of service for the terraces.

E X P E R I M E N T No. 4

Level Terraces With Closed Ends

This experiment yields information concerning the design of level terraces in which the ends are closed and all the rainwater retained. The effect upon crop yield of conserving all the rainfall, and the extent of injury to crops by water standing in terrace channels is studied in relation to these terraces.

Terraces 1-F, 2-F, 3-F, located almost entirely upon virgin soil, comprise the layout for this experiment. Terraces 1-F and 2-F encircle the hilltop at the center of the farm and Terrace 3-F is located at north end of the central ridge. The average slope of land above the terraces is 1.1, 3.3, and 1.6 per cent for Terraces 1-F, 2-F and 3-F, respectively. A record of crops planted and resulting yields is listed in the following table:

CROP YIELDS * TERRACES 1-F 2-F 3-F							
Terrace		1-F		2-F		3-F	
Division		Normal	Subsoiled	Normal	Subsoiled	Normal	Remarks
Year	Crop	Per Acre	Per Acre	Per Acre	Per Acre	Per Acre	
1929	Cotton	83.4		70.8		143.0	lbs. of lint cotton
1930	Oats	17.2	16.5	17.2	16.5	31.0	bushels of oats
1931	Cotton	232.8	214.8	163.8	189.3	206.5	lbs. of lint cotton
1932	Corn	11.0	9.5	4.5	6.9	Killed by Chinch Bugs	Bushels of corn

Note: Subsoiling was done after harvesting cotton in 1929, and before planting corn in 1932.

During the spring of 1929, water stood above these terraces

for several days after a heavy rain, damaging the crop in the terrace channel and causing a delay in tilling the land and planting the crop. In the spring and early summer of 1930 a large amount of rainfall occurred and as a result water stood in the channels of the terraces continuously for over a month, drowning practically all of the oats in the channel.

For the year 1931 the spring rainfall was below normal. However, water stood in the channels fwom sixteen to twenty-one days. This period occurred just before cotton planting time and neither delayed planting the crop nor subjected the crop to drowning at any time. Even with such an ideal season as this to provide for the conservation of moisture, a comparison with adjoining graded Terrace 1-C on virgin land shows a yield of 211 pounds of lint cotton per acre as contrasted to 200 pounds per acre for the weighted average terraces of 1-F, 2-F, and 3-F. This indicates that on this particular soil the storage of water by closed level terraces is not an important factor in determining an increased crop yield.

As a result of the series of intense rains which occurred after May 31, 1932 the channels of Terraces 1-F, 2-F and 3-F, were filled with water practically continuously until the middle of July. This resulted in the complete loss of all crop in the terrace channel as shown in the following table:

TERRACES 1-F 2-F 3-F - Year 1932

Corn Yields on Terrace Channel, Ridge, and Interval

Terrace	1-F		2-F		3-F
Division	Normal	Subsoiled	Normal	Subsoiled	Normal
Ridge	15.1	14.1	7.5	14.1	Killed by chinch bugs
Channel	0.9	0.0	0.4	0.0	
Interval	11.4	9.6	3.5	5.2	

The maximum depth of water in the channels of these terraces following the major rains was so great during the spring of 1932 that the waterline was at times level with the ridge top. Evaporation and percolation lowered this level sufficiently, to prevent overtopping by the next rain. The terraces at this time were maintained to an average height of 1.40 feet for Terrace 2-F and 1.50 feet for Terrace 1-F.

An impervious subsoil underlaid by sandstone is held responsible for the water standing in the terrace channels so long after rains. That portion of the land above Terraces 1-F and 2-F and north of the central dyke, see map Figure 1, was subsoiled to a depth of about 14 inches in the fall of 1929 and again in the spring of 1932. This operation seemed to have no great beneficial effect upon the crop yield during any of the years of record.

In both 1931 and 1932 the water disappeared from the channels of the subsoiled areas from one to five days sooner than from those of the normal area. During certain periods of the year, such as those of planting and harvesting, this short additional time might prove of great value.

Information thus far obtained upon level terraces with no outlet on the erodedsoil of the Guthrie farm dictates that they are not satisfactory for the following reasons:

1. Terraces of excessive height or extremely small vertical spacing are required.

2. There is a serious decrease in crop yields due to drowning of crop in the channel and delay in harvesting operations.

3. Wet terrace channels hinder the accomplishment of farm operations at the proper time.

It is possible that during extremely dry years the conservation of moisture above these level terraces might tend to increase crop yields as compared with graded terraced land. To date there has been no data to prove this possibility.

It is possible that during extremely dry years the sub-irrigation of meadows along these creek terraces might tend to increase crop yields as compared with graded bottomland land. No data have been made to prove this possibility.

E X P E R I M E N T No. 5

Short Level Terraces With Closed Ends and Long Terraces of Different Lengths With Open Ends

Information from this experiment indicates the economical length and spacing of level terraces on eroded land for the particular soil and slope of this experiment. Conclusions are also made in regard to the effect upon crop yields of preventing any run-off by means of the level terrace with closed ends, of permitting some run-off by leaving the end of the level terraces open, and of no artificial obstruction to run-off in the case of land not terraced.

Level Terraces 1-E to 10-E, studied in this experiment vary in length from 250 feet to 650 feet. Starting with Terrace 10-E at the foot of the slope the vertical intervals vary as follows: two feet, two and one half feet, three feet, three and one half feet, four feet, two feet, two and one half feet, two and one half feet, and two feet. The north ends of these terraces are closed and a small embankment is built 100 feet from the north end so that all the rainfall on this strip is retained. This embankment is about three inches lower than the terrace ridge which prevents overtopping of the terrace. The strip of closed end terraces is designated as Plot 14, the unterraced areaon the north as Plot 13, and the open end level terraces on the south as Plot 15, (See Map, Figure 1).

Cowpeas were planted in 1929 immediately after the spring rains and as a result did not suffer loss from standing water. On the other hand there was no apparent increase of yield due to increased soil

moisture. Cotton was planted on this land in the spring of 1930 but not all of the terrace channels could be planted because they remained wet during the planting period. This resulted in a low yield of cotton per acre. Cowpeas were again planted for the year 1931 and suffered serious reduction of yield in the channel area due to standing water during the period April 16th to May 12th. Cotton planted in 1932 also produced low yields due to the complete loss of the crop in terrace channels as a result of continuous standing water over the period May 31st to June 15th. Crop yields for Plots, 13, 14 and 15, during the four years of record are listed in the following table:

CROP YIELDS - PLOTS 13, 14, And 15

Year	Crop	Plot 13	Plot 14	Plot 15	Remarks:
1929	cowpeas	462	197		Pounds of shelled peas per acre
1930	Cotton	107	75	80	Pounds of lint cotton per acre
1931	cowpeas	655	376	319	Pounds of shelled peas per acre
1932	Cotton	120	77	91	Pounds of lint cotton per acre

Detailed records of lint cotton yields for terrace ridge, channel and interval for both Plots 14 and 15, are listed in the following table:

P L O T S 14, AND 15.

Lint Cotton Yield - Terrace Channel, Ridge, and Interval, 1932						
	Plot 14			Plot 15		
Terrace	Ridge	Channel	Interval	Ridge	Channel	Interval
2-E	122	0	50	190	107	101
3-E	83	0	53	147	39	73
4-E	109	0	42	127	53	68
5-E	136	5	56	130	28	23
6-E	139	0	96	112	19	52
7-E	144	0	101	120	34	58
8-E	111	0	33	156	67	70
9-E	94	31	57	103	78	69
10-E	123	16	46	83	57	21

Comparison of the yields from the two plots shows similar yields on ridge and interval but channel yields in Plot 14 were completely destroyed while those in Plot 15 were equal to the interval yields.

Terrace in Plot 15, while level with open ends, suffer considerable loss of yield through the action of water standing in the low places at old gully crossings. The area was severely gullied prior to terracing and as a result the channels are very irregular. Also a large amount of the top soil was used in making the large fills across gullies. The drowning of crops in the channels of terraces in Plots 14 and 15 has kept the per acre yields from these terraces consistently lower than those of Plot 13 with no terraces.

The depth of water in all the level terraces with closed ends became sufficiently great to cause flow over the end embankments and would have readily overtopped the terrace ridge had the embankments not been placed below the level of terrace ridge top.

A group of short level terraces with closed ends were constructed in 1930 on Plot G, and are designated on the map as Terraces 2-G to 5-G inclusive. Field G-1 serves as an unterraced check. The virgin land used in these fields was in woods and brush which was removed just before the terraces were built. Measurements of water standing in the channels, and of crop yields are made to compare with Terraces 2-E to 10-E on severely eroded land.

During the year 1931 water stood in the channels of these terraces for only four days following the period of greatest rainfall and consequently did not damage the crop of cowpeas. The channels were dry enough for the performance of normal farm operations very shortly after the last standing water disappeared. This quick absorption of excess precipitation is marked when compared with the long periods during which water stands in the channels of corresponding terraces on eroded land. The average yield of cowpears per acre on the closed end terraces was 485 pounds per acre for the year 1931 as compared with 1096 pounds per acre on the unterraced check. This great difference may be due to the fact that the soil disturbed b y the terracing operation had not yet had time to regain its productivity. For 1932, the average yield of lint cotton on the terraced plot was 125 pounds per acre as compared with 168 pounds per acre on the plot

The depth of water in all the level terraces with closed ends became sufficiently great to [illegible] would have readily [illegible] below the level of terrace ridge [illegible].

A group of short level terraces with closed ends were constructed in [illegible] on Plot [illegible] to [illegible]. Field [illegible]. The [illegible] land used in these fields [illegible] before the terraces were built. [illegible] in the channels, [illegible] on [illegible] land.

During the year 1931 water stood in the channels of these terraces for only four days following [illegible] and [illegible] did not damage the crop of cowpeas. The channels were dry enough for the performance of normal farm operations [illegible] the last standing water disappeared. This quick absorption of excess precipitation is marked when compared with the long periods [illegible] water stands in the channels of corresponding terraces [illegible]. The average yield of cowpeas per acre on the closed end terraces was 485 pounds per acre for the year [illegible] as compared with [illegible] pounds per acre on the unterraced check. This great difference may be due to the fact that the soil was disturbed by the terracing operations [illegible] its productivity. For [illegible], the average yield of [illegible] on the terraced plot was [illegible] pounds per acre as compared with [illegible] pounds per acre on the [illegible]

not terraced, indicating that the terraced land had begun to recover its full productivity while the unterraced area had no doubt lost through erosive action.

The channels of the G terraces would retain standing water for from one to five days following each of the major storms occurring during the spring and summer of 1932, but it appears that the sum of these periods was sufficient to cause some reduction in crop yield in the channel. The following table lists cotton yields for the terrace ridge, channel, and interval for the year 1932:

YIELDS OF LINT COTTON - TERRACES 2-G to 5-G 1932

Terrace	PLOT G			Plot G-1
	Ridge	Channel	Interval	Not Terraced
2 - G	205	51	256	168
3 - G	189	38	112	
4- G	152	42	70	
5 - G	202	60	76	

Conclusions from this experiment in regard to closed and terraces on eroded land are quite definitely in line with those from the preceding experiment as follows;

1. Terraces of excessive height or extremely small vertical spacing are required.

2. There is a serious decrease in crop yields due to drowning of crop in the channel and delay in harvesting and planting.

3. Wet terrace channels hinder the accomplishment of farm operations at the proper time.

Sufficient data has not been obtained from the level terraces on virgin land to serve as a basis for definite conclusion. The following trends are outlined:

1. Absorption takes place at a sufficiently rapid rate to prevent the necessity of unusually high terraces or close spacings.

2. There is some decrease in crop yield due to the standing water during wet years.

3. It may be possible that during years of scant rainfall the conservation of moisture will be of benefit to crops.

E X P E R I M E N T No. 6

Terraces With Different Grades on Badly Eroded Land

It is desired to determine the most satisfactory grade for terraces on badly gullied slopes similar to that on which this experiment is located and the time required to fill gullies above terraces with soil deposited by washing and blowing.

Terraces 5-B to 9-B inclusive, located on the badly gullied slope in Field E on the west side of the farm comprise the layout for this experiment. They vary in length from 1,125 to 1,937 feet and the grades are as follows: 5-B and 6-B vary from level to four inches per 100 feet; 7-B from level to three inches; 8-B from level to two inches; 9-B is a level terrace. All of the terraces cross land which is cut by deep gullies and severely damaged by sheet erosion.

Run-off from these terraces was carefully observed after principal storms for the years 1931 and 1932 and the following conclusions drawn:

1. The run-off water from Terrace 8-B with a maximum grade of two inches per 100 feet and from level Terrace 9-B appeared to contain less soil than the run-off from the remaining graded terraces.

2. Run-off from Terraces 8-B and 9-B did not reach maximum depths in the channels equal to those in the other terraces thus indicating lower intensities and less opportunity for erosion.

3. On these same two terraces run-off would continue longer following any storm than was the case on the other terraces in the experiment, thus affording opportunity for greater percolation into the soil.

4. There did not appear to be any appreciable difference in damage to crops by run-off water from any of the terraces in this experiment.

5. The period of time following any storm before farm operations could be resumed in the channels was about equal for all the terraces.

Soil borne by wind and run-off water has been deposited in the depressions left at points where there terraces crossed gullies. In the two years which have elapsed since the construction of the terraces this deposition has been sufficient to completely obliterate many of the depressions left by the smaller gullies. The depressions caused by the larger gullies have been filled sufficiently to prevent serious damage to crops by standing water. These soil deposits in many cases are from one to two feet in depth. See Figure 19, for profiles of these terraces as taken in 1929 and early in 1933.

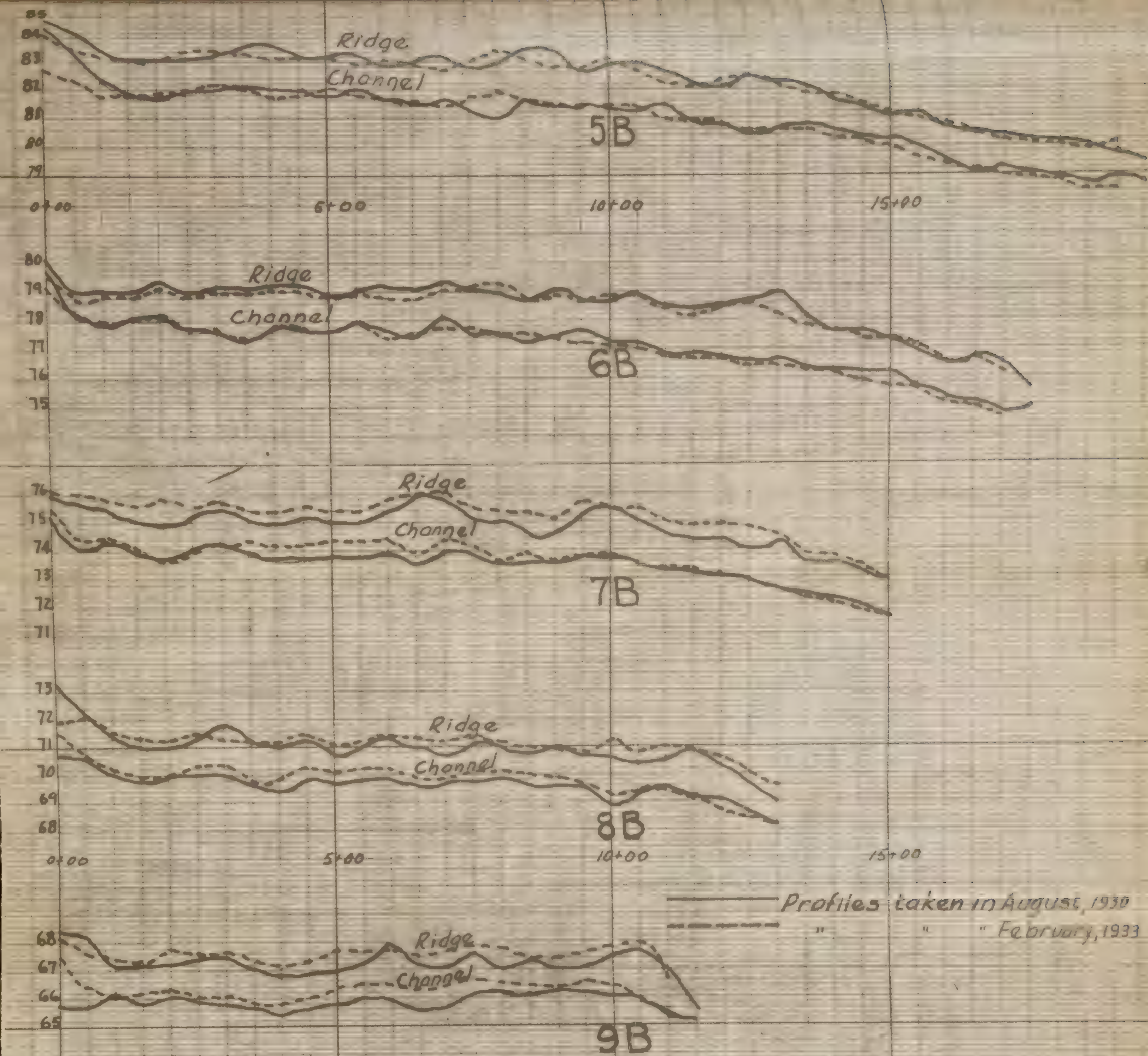


FIGURE - TERRACE PROFILES, FIELD E,
RED PLAINS SOIL EROSION EXPERIMENT STATION

E X P E R I M E N T No. 7

Construction of Terraces - Methods and Cost

It is necessary that information be obtained on the most economical methods, the most satisfactory machines, and the most efficient cross section for use in terrace construction. Data of this type was ~~analyzed in the report for the years 1929 and 1930, summation~~ secured for all terraces built on the Guthrie erosion farm and was analyzed in the report for the years 1929 and 1930. A summation of this data is presented in Table 6.

In order that this information may be expanded to cover all desirable methods, implements, and designs, additional terrace construction work is done from time to time on nearby farms, under the supervision of the Bureau of Agricultural Engineering. Summations of such data secured during the years prior to 1932 are also listed in Table 6.

It has been the practice at the Guthrie Station to try out all new type terracing machines so that their comparative efficiency and cost of operation might be determined. The construction of terraces on the Guthrie station farm during the years 1929 and 1930 was conducted largely with the Martin Ditcher and Corsicana terracer with results as listed in Summary Table No. 6. Work for the years 1931 on outside farms was conducted with the Caterpillar 8 foot blade terracer and with large county road machinery.

Terrace construction work during the year 1932 was devoted entirely to comparisons of the one way Wheatland Disc Plow with 26 inch

E X P E R I M E N T N O. 7

Construction of Terraces - Methods and Cost

It is necessary that information be obtained on the most economical methods, the most satisfactory machines, and the most efficient cross section for use in terrace construction. Data of this type was [illegible] obtained for all terraces built on the Guthrie station farm and was analyzed in the report for the years 1930 and 1931. A summary of this data is presented in Table 6.

In order that this information may be expanded to cover all desirable methods, implements, and heights, additional terrace construction work is done from time to time as needs arise, under the supervision of the Bureau of Agricultural Engineering. Summaries of each data secured during the years prior to 1933 are also listed in Table 6.

It has been the practice at the Guthrie Station to try out all new type terracing machines so that their comparative efficiency and cost of operation might be determined. The construction of terraces on the Guthrie station farm during the years 1930 and 1931 was conducted largely with the Martin Ditcher and Terracer and [illegible] terracer with tractor as listed in Summary Table No. 4. Work for the years 1932 on station farms was conducted with the Caterpillar 8 foot blade terracer and with large county road machinery.

Terrace construction work during the year 1933 was devoted entirely to comparisons of the one way [illegible] with [illegible]

TABLE No. 6
SUMMARY OF TERRACE CONSTRUCTION COSTS
Red Plains Soil Erosion Experiment Station Near Guthrie, Oklahoma

Name of Farm	Terraces	Acres Terraced	Cost Per Acre: Grading	Cost Per Acre: Fill	Cost Per Acre: Total	Cost Per Mile: Grading	Cost Per Mile: Fill	Cost Per Mile: Total	Average Land Slope Per Cent	Size of Terrace: Average Height	Size of Terrace: Average Width	Machinery Used	Description and Condition of Soil
Guthrie Station	1A to 10A	11.93	12.44	none needed	12.44	101.75	none needed	101.75	5.6	1.7	20	Martin Ditcher - John Deere Tractor "15"	Sandy loam soil, newly cleared land, with stumps, rock and roots
"	2B to 4B	18.62	3.06	1.96	5.02	36.38	23.30	69.68	3.6	1.3	26	8-foot Corsicana - John Deere Tractor 15	Badly eroded sandy clay soil with few shallow gullies
"	5B to 9B	13.98	5.94	8.61	14.55	57.48	83.40	140.88	4.9	1.6	25	8-foot Corsicana - John Deere Tractor 15	Badly eroded sandy clay soil with numerous deep wide gullies
"	1E to 10E	9.13	6.03	4.27	10.30	56.56	40.30	96.86	3.9	1.5	20	8-foot Corsicana - John Deere Tractor 15	Badly eroded sandy clay soil with numerous deep gullies
"	1C to 2C	7.12	4.49	2.46	6.95	50.17	27.50	77.67	4.2	1.6	27	Martin Ditcher and 8-foot Corsicana - John Deere Tractor "15"	Old cultivated field and pasture with few small gullies
"	1C to 2C and 1F to 2F	4.42	7.41	none needed	7.41	72.02	none needed	72.02	2.7	1.5	27	Martin Ditcher and 8-foot Corsicana - John Deere Tractor "15"	Newly cleared land with stumps and roots, virgin
"	3C to 6C	12.99	3.99	2.51	6.50	38.67	24.30	62.97	4.6	1.5	26	Martin Ditcher and 8-foot Corsicana - John Deere Tractor "15"	Old cultivated field & pasture with few gullies, more than half virgin, remainder (eroded
"	1G to 6G	4.80	5.93	none needed	5.93	53.64	none needed	53.64	4.3	1.4	22	Martin Ditcher - John Deere Tractor "15"	Newly cleared land with stumps and rocks.
Above costs include Fuel and Repairs but not interest and depreciation on Machinery													
Sutton		4.90	0.54	0.61	1.15	8.67	9.93	18.60	3.0	1.4	26	26-inch one way plow - Caterpillar "15" Tractor	Loose sandy loam, excellent condition for terracing
Borgman		10.60	0.83	1.13	1.96	18.70	25.50	44.20	3.0	1.3	25	Caterpillar Terracer and 15 Tractor	Sandy loam, good condition.
Luckenbill		11.50	1.80	1.00	2.80	4.05	2.26	6.31	5.0	1.3	28	Stockland 12-foot blade grader - Caterpillar "60" Tractor	Loose top soil, heavy subsoil, good condition
Allen		30.00	0.97	0.13	1.10	16.11	2.17	18.28	6.0	1.4	24	" " " "	Soil hard and dry, sand rock exposed in places, gullies
Egleston		14.00	0.80	none needed	0.80	13.01	none needed	13.01	3.4	1.2	24	" " " "	Loose sandy soil in excellent condition
Gooch		81.00	0.76	0.67	1.43	9.47	8.39	17.86	5.4	1.2	24	" " " "	Soil hard and dry, sandy, gullies.
Burst		55.00	0.52	0.44	0.96	8.63	7.25	15.88	4.5	1.0	23	" " " " and one way plow - Caterpillar "15" Tractor	Soil in fair condition, gullies.
Faulkner		19.50	0.75	0.16	0.91	13.55	2.89	16.44	3.1	1.5	29	" " " "	Soil in good condition, gullies.
Allen		2.60	0.68	not	no	9.30	not	no	6.0	1.3	24	26-inch one way plow - Caterpillar "15" Tractor	Badly gullied soil in good condition
Simpson		57.00	0.81	done	Record.	11.53	done	record	4.0	1.2	27	Caterpillar 8-foot blade grader and "15" Tractor	Condition of soil excellent for terracing although slightly wet, gullied.
Elliott		11.20	1.25	"	"	11.75	"	"	3.5	1.2	30	Caterpillar "15" Tractor, Caterpillar Terracer, Moline 26-inch one way plow, Rumely Oil Pull Tractor, Case 23-inch one Way Disc Plow	Moist but not wet, ideal for blade machine but too moist for disc.

Stockland grader and "60" Caterpillar tractor owned by county for which no charge was made and above costs includes only fuel for tractor. Other costs above include fuel and repairs but not interest or depreciation on machinery.

and 23 inch discs, and to the Caterpillar Terracer with eight foot blade. This work was conducted on the Borgman, Faulkner, Allen and Elliott farms, all located conveniently near the Red Plains Soil Erosion Experiment Station. Detailed cost and construction data from this work is listed in Table 7.

The application of machines which serve routine duties in farm operations to the construction of terraces is a study worthy of much consideration. It is obvious that the first cost, depreciation and upkeep of such machines would not have to be charged entirely to one operation and consequently should be highly economical. The one-way disc plow is used extensively for the preparation of land in the wheat regions of the middle west and appears to offer possibilities for development as an efficient terracing machine. Accordingly several terracing projects were conducted during the years 1931 and 1932 with the Moline 26 inch one-way disc owned by the Guthrie station. It is planned to supplement these studies during the year 1933 with tests of a Case 23 inch one-way disc plow.

Discussion of 1932 Terrace Construction.

The first project for the year was conducted on the Borgman farm on severely eroded and gullied land. Terrace B-1 on this soil in good condition was constructed for $16.16 per mile, while terraces B-2 and B-3 which passed through a 100 yard deposit of windblown sand on a north facing slope cost $21.38 and $17.58 per mile, respectively. The deep and loose sand caused the terracer to bog down and make accurate control of the blade impossible. All terraces constructed averaged 15 to 16 inches high and 25 feet in width. The cost per mile of terrace for all terraces so far

and 29 inch discs, and to the Caterpillar tractor with eight foot blade. This work was conducted on the Ferguson, [illegible], Allen and Elliott farms, all located conveniently near the Red Plains Soil Erosion Experiment Station. Detailed cost and construction data from this work is listed in Table 9.

The application of machines which serve routine duties in farm operations to the construction of terraces is a study worthy of much consideration. It is obvious that the first cost, depreciation and upkeep of such machines would not have to be charged entirely to the terracing and consequently should be highly economical. The one-way disc plow is used extensively for the preparation of land in the wheat regions of the middle west and appears to offer possibilities for development as an efficient terracing machine. Accordingly several terracing projects were conducted during the years 1931 and 1932 with the Wallis 24 inch one-way disc owned by the Guthrie station. It is planned to supplement these studies during the year 1933 with tests of a Case 22 inch one-way disc plow.

Discussion of 1932 Terrace Construction.

The first project for the year was conducted on the Ferguson farm on severely eroded and gullied land. Terrace F-1 on this soil in good condition was constructed for $14.34 per mile, while terraces F-2 and F-3 which passed through a 100 foot [illegible] of windblown sand on a [illegible] slope cost $21.32 and $17.68 per mile, respectively. The loose and fine sand caused the terraces to lay down and made accurate control of the discs impossible. All terraces constructed averaged 15 to 16 inches high and 30 feet in width. The cost per mile of terrace for all terraces so far

TABLE No. 7

COST OF TERRACE CONSTRUCTION - BORGMAN, FAULKNER, ALLEN AND ELLIOTT FARMS

Work Conducted by Bureau of Agricultural Engineering - Red Plains Soil Erosion Experiment Station.

Terrace Number.	Machine Used.	Length of Terrace	Size Of Terrace. Height in Feet	Width in Feet.	Terrace Data: Slope of Land Ft/100'	Vertical Interval in Feet	Linear Feet Of Terrace Per Acre	Work Per 100 Feet of Terrace: Machine Hours: Tractor	Machine Hours: Grader	Man Hours: Tractor	Man Hours: Grader	Cost of Terrace Without Scraper: Per 100'	Per Mile	Per Acre	Condition of Soil	Surface Cover	Method of Construction
								BORGMAN FARM									
B-1	A	785	1.30	25	3.0	3.5	- -	0.34	0.34	0.34	0.34	0.31	16.16	- -	Good	None	Both sides only - 12 rounds
B-2	A	1035	1.30	25	3.0	3.5	- -	0.45	0.45	0.45	0.45	0.40	21.38	- -	300' Sand	None	Both sides only - 13 rounds
B-3	A	675	1.30	25	3.0	3.5	- -	0.37	0.37	0.37	0.37	0.33	17.58	- -	200' Sand	None	Upper side only - 13 rounds
											Grading	Fill	Total				
						0.47 miles of terrace on)			Per Acre		0.83	1.13	1.96				
						10.6 acres at average cost)			Per Mile		18.70	25.50	44.20				
								FAULKNER FARM									
F-1	A	900	1.42	30	- -	- -	257	0.31	0.31	0.31	0.31	0.28	14.73	0.72	Very Good	Wheat	Both sides only - 12 rounds
F-2	A	1160	1.87	20	2.8	3.5	322	0.44	0.44	0.44	0.44	0.40	20.91	1.27	" "	Stubble	Upper side only - 15 rounds
F-3	A	1740	1.43	30	3.0	3.0	352	0.24	0.24	0.24	0.24	0.22	11.40	0.76	" "	and	Upper side - 11 trips - 10 rounds
									Plow		Plow						Lower side - 9 trips
F-4	B	1000	1.60	30	3.0	3.0	270	0.26	0.26	0.26	- -	0.16	8.24	0.42	" "	Weeds	Both sides only - 12 rounds
F-5	B	900	1.32	34	3.7	3.0	237	0.32	0.32	0.32	- -	0.19	10.14	0.45	Some Small	"	Both sides only - 15 rounds
											Grading	Fill	Total		Gullies		
						1.08 miles of terrace on)			Per Acre		0.75	0.16	0.91				
						19.5 acres at average cost)			Per Mile		13.55	2.89	16.44				
								ALLEN FARM							Severely		
									Plow		Plow				Eroded		
A-1	B	450	1.37	24	6.0	- -	- -	0.32	0.32	0.32	- -	0.19	10.14	- -	With Gul-	Weeds	Both sides only - 14 rounds
A-2	B	550	1.30	24	6.0	4.0	- -	0.29	0.29	0.29	- -	0.17	9.19	- -	lies and		Both sides only - 14 rounds
											Grading	Fill	Total		Exposed		
						0.19 miles of terrace on)			Per Acre		0.68	not done	0.68		Rock		
						2.6 acres at average cost)			Per Mile		9.30	" "	9.30				
								ELLIOTT FARM									
																	Both sides equally - 10 rounds
E-1A	A	469	1.47	32	0 to 3.7	4' to top	768	0.405	0.405	0.405	0.405	0.364	19.25	2.81	Moist but	Sudan	Upper side only - 4 rounds
E-2A	B	772	0.97	34	3.7	3.0	642	0.421	- -	0.421	- -	0.253	13.37	1.63	not wet,	Stubble	Both sides equally - 18 rounds
E-3A	A	880	1.48	30	5.0	4.0	567	0.341	0.341	0.341	0.341	0.307	16.22	1.74	Ideal for	"	Both sides equally - 10 rounds
															blade		Upper side only - 4 rounds
E-1B	B	575	1.31	27	0 to 3.8	3.0	411	0.290	- -	0.290	- -	0.174	9.20	0.71	machine	Kaffir	Both sides equally - 12½ rounds
E-2B	A	1064	1.41	32	3.8	3.0	682	0.282	0.282	0.282	0.282	0.254	13.42	1.74	but al-	Stubble	Both sides equally - 9 rounds
															most too		Upper side only - 3½ rounds
E-3B	D	1400	0.99	30	3.1	3.5	460	0.250	- -	0.250	- -	0.150	7.92	0.69	moist for	"	Both sides equally - 12½ rounds
E-4B	C	1115	0.97	28	4.0	3.0	598	0.269	- -	0.269	- -	0.163	8.61	0.97	one way	"	Both sides equally - 9½ rounds
											Grading	Fill	Total		disc.		
						1.19 miles of terrace on)			Per Acre		1.25	not done	1.25				
						11.2 acres at average cost)			Per Mile		11.75	" "	11.75				

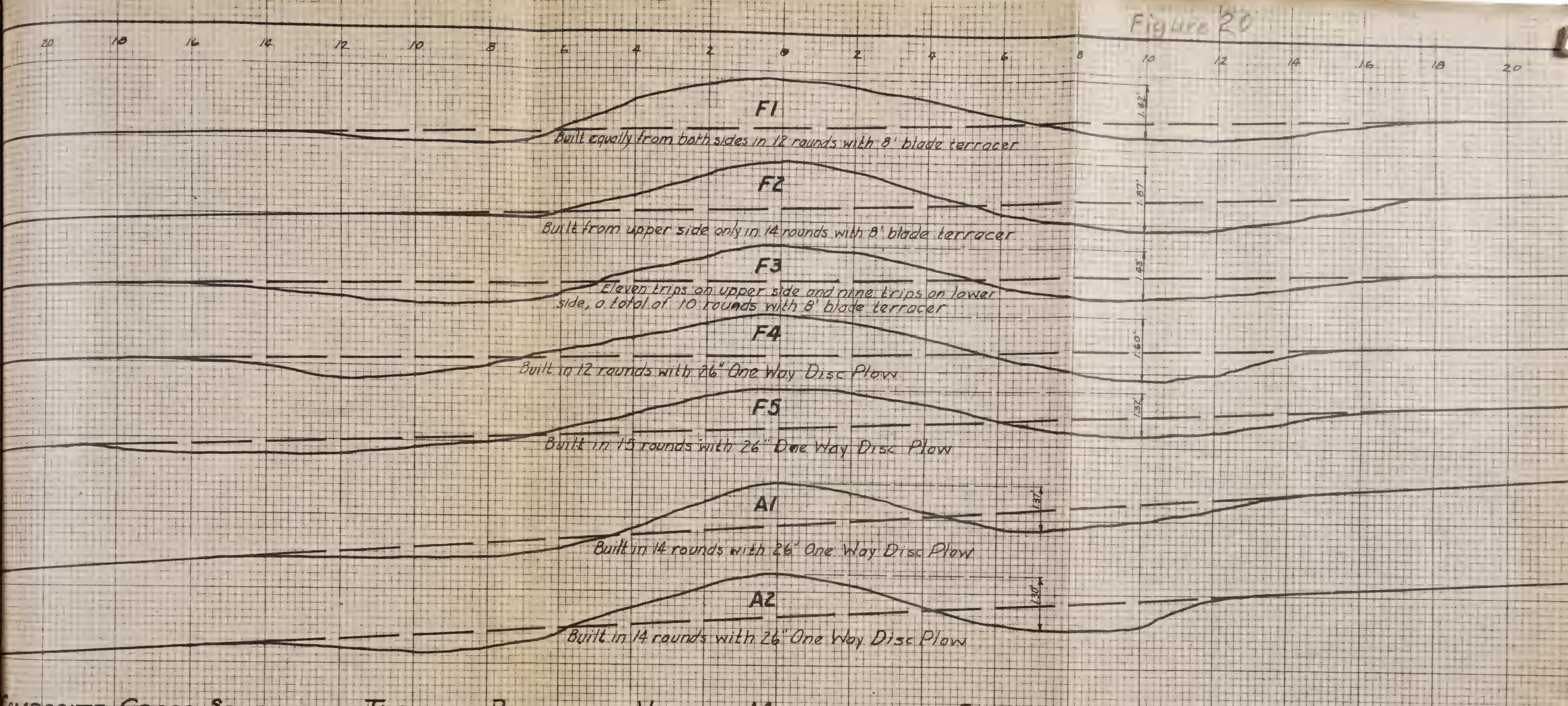
Machine Notations:
A = Caterpillar 15 Tractor and Caterpillar Terracer
B = Caterpillar 15 Tractor and Moline 26", One Way Disc Plow
C = Rumely Oil Pull 25 Horsepower Tractor and Moline 26", One Way Disc Plow
D = Rumely Oil Pull 25 Horsepower Tractor and Case 23", One Way Disc Plow

Labor = $ 0.30 per hour
Tractor = 0.30 per hour

constructed with Caterpillar terracer has varied from a minimum of $11.40 per mile to $21.38 per mile, dependent largely on the type of soil and topography encountered, and the skill of the operators. The size of the terraces was kept uniform as near as possible.

Terraces constructed on the Faulkner farm were the second project for the year. Five terraces with a total length of 1.08 miles were built on 19.5 acres of land at an average cost of $13.55 per mile for grading and $2.89 for fill work or a total of $16.44 per mile. The soil encountered on this farm was a Kirkland fine sandy loam in a dry condition with some Rocky Mountain outwash material in places on the higher knolls. There had been no serious damage by erosion. The topography was of a uniform rolling type, ideal for rapid terrace construction.

Terraces F-1, F-2 and F-3 were constructed with the Caterpillar Terracer drawn by a Caterpillar 15 tractor. Terraces F-4, and F-5 were constructed on the same soil and slope with the Moline 26 inch one-way disc plow and Caterpillar 15 tractor. See Figure 20 for comparative composite cross sections of these terraces. The cost of grading per mile on Terrace F-1, was $14.73, on Terrace F-2 was $20.91, and on Terrace F-3 was $11.40. Similar costs on Terraces F-4 and F-5 were $8.24 and $10.14 respectively. Approximately the same number of rounds was required for each machine on similar terraces but the difference in cost was derived from the fact that two men were required to operate the blade terracer and tractor whereas one man could operate the one-way plow and tractor.



COMPOSITE CROSS-SECTIONS OF TERRACES BUILT WITH VARIOUS MACHINES ON THE FAULKNER AND ALLEN FARMS, GUTHRIE, OKLAHOMA.

Terrace F-1 was built equally from both sides, Terrace F-2 from upper side only, and terrace F-3 was built with eleven trips on the upper side and nine on the lower side for a total of ten rounds. The composite cross sections of these terraces in Figure 20, show a great deal more channel room on the terrace built from the upper side only. The slope of land on all three terraces was 3.0 per cent or less. This data strengthens the conclusions reached in the work of 1929, 1930, and 1931, that terraces may be built more cheaply from the upper side, when the land slope is greater than four per cent. On slopes less than four per cent, more economical results are obtained by building the terrace practically equally from both sides. When using the one-way disc plow, it is necessary to work equally from both sides of terrace since the plow can not be reversed.

The two terraces built on the Allen farm with the 26 inch one-way disc plow brought out the fact that this machine performs satisfactorily on slopes of six per cent and on severely eroded land with rock exposed. The soil was dry and hard. The costs were only $10.14 and $9.19 per mile for grading work. Figure 20 shows by composite cross sections that these terraces were of satisfactory section.

The basic aim of the terrace construction work on the Elliott farm was to secure a strict comparison of the 8 foot blade terracer and the 26 inch one-way disc. The soil on Elliott Field A was severely eroded and gulled and was quite moist, though ideal for blade operation. The soil under this condition proved to be too sticky for the discs, causing them to clog full of dirt and thus lose all dirt moving action, (See figure 21). Terraces E-1-A and E-3-A were built with the 8 foot blade machine, in 14 and 13 rounds, and are

Figure 21: Wheatland one-way disc plow working in moist soil on the Elliott farm. The discs are badly clogged with the sticky earth and are no longer efficient as dirt movers.

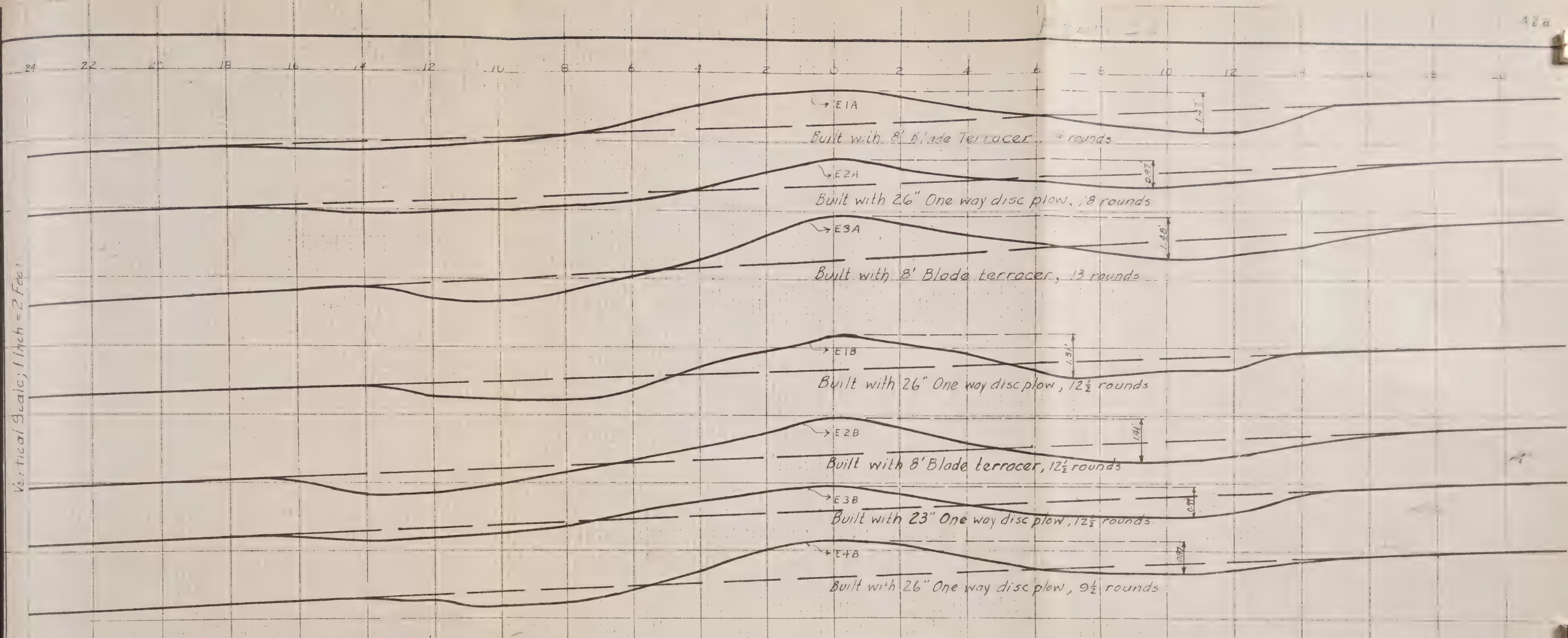
of good height and substantial section according to the composite cross section in Figure 22. Terrace E-2-A, built with the one-way disc plow, had low height and channel capacity according to the composite section. There were 18 rounds made on this terrace but they were not effective because of the moist dirt clogging the discs.

Terraces E-1-B, E-2-B, and E-3-B, and E-4-B, were located in Elliott Field B, which was not severely eroded. The soil was not as moist as that in Elliott Field A, and did not contain as much sticky clay.

Terrace E-1-B was built in 12½ rounds with the one-way 26 inch disc plow at an average cost of $9.20 per mile. Terrace E-2-B was built in 9 rounds with the eight foot blade terracer at an average cost of $13.42 per mile. The two terraces are comparable in soil and cross section (See Figure 22) but E-1-B was shorter with a greater percentage of time loss on turns.

Terrace E-3-B was built in 12½ rounds with a Rumely Oil Pull tractor of 25 horsepower and a Case one-way disc plow using discs 23 inches in diameter. Terrace E-4-B was built in 9½ rounds with the same tractor and the Moline one-way disc plow using 26 inch diameter discs. The resulting cross sections of these terraces are similar (See Figure 22), but are not of satisfactory height or volume. Since these two terraces do not give a good comparison of the efficiency of the 23 and 26 inch discs, it will be necessary to study this subject by more construction during 1933.

At the time terraces were first built with the one-way disc plow, it was suggested that the resulting ridge, being loose, would lose



COMPOSITE CROSS-SECTIONS OF TERRACES BUILT WITH VARIOUS MACHINES ON THE ELLIOTT FARM NEAR GUTHRIE, OKLAHOMA

most of its effective height by settling. Surveys were made to determine the change in height of the Faulkner terraces after they had stood for six months, with results as shown in the following table:

HEIGHTS OF FAULKNER TERRACES

Terrace	Machine used: to construct	Original height	Height after settlement	Decrease of height	Percentage decrease
F - 1	8" blade ter	1.42	1.20	0.22	15.5
F - 2	"	1.87	1.40	0.47	25.1
F- 3	"	1.43	1.23	0.20	14.0
F - 4	26" disc	1.60	1.20	0.40	25.0
F - 5	"	1.30	1.00	0.30	23.0

These data indicate that there is little difference in the rate of settlement of the terraces built with the two machines.

Conclusions:

The construction of terraces on the Red Plains Soil Erosion Experiment Station and on neighboring farms has provided the following conclusions as to methods and costs:

1. Cost of terrace construction will vary greatly with the experience, skill, intelligence, and vigor of the machinery operators.

2. Soil extremely dry and hard or extremely moist will increase the cost of construction.

3. A vegetative covering that will clog the machinery tends to slow down the rate of construction.

4. Short terraces are more expensive to construct than long terraces due to the increased percentage of time spent in turns.

5. Cost of construction per mile of terrace, not including depreciation of machinery, will decrease as the size of the terracing machine is increased, provided sufficient traction power is always supplied.

6. Satisfactory terraces may be built with any machine from the two horse moldboard plow to the 14 foot grader, providing the proper amount of perseverance is applied.

7. It requires more time and labor to build a terrace in heavy clay than in a sandy loam soil.

8. Roots, rocks, sprouts, and stumps add materially to the cost of terracing.

9. It costs about twice as much to terrace cultivated land with small gullies as it does to terrace cultivated land of a uniform nature. This ratio rapidly increases with the number and size of the gullies.

10. Terracing costs secured on soil of one definite texture and workability will not be applicable to a soil of another texture and degreeof workability.

11. On slopes of less than about four per cent it is more economical to build terraces from both sides equally, but when the slope exceeds this amount, it is cheaper to work from the upper side only.

12. Large road machinery will building terraces on hard, rocky ground not workable with small machinery.

13. The one-way disc plow, using discs 26 inches in diameter, will build terraces equivalent to those built with the blade terracer in approximately the same numer of rounds. Only one man is required to operate the unit of tractor and one-way disc while two are required to operate the tractor and blade terracer. It is subject to a major disadvantage, however, in that it will not function efficiently on wet or very damp ground that may be easily worked with a grader.

E X P E R I M E N T N o. 8.

Study of Farm Operations and Machinery on Terraced Land.

The object of this experiment is to determine the most effective and economical methods for preparation of seed bed, planting, cultivation, and harvesting of crops on terraced land. An effort is also made to suggest improvements in the design of machinery that will answer the requirements of farming parallel to the type of terrace ridge found most satisfactory for this locality.

The major crops raised in this section of the country are cotton, oats, corn, wheat, grain sorghums, and the various legume crops of alfalfa, sweet clover, soybeans, mungbeans, and cowpeas. These crops are nearly equally divided into row crop and drilled crop cultivation and as a result it is necessary to study and operate both types of machinery. Most cultivated fields are of comparatively small acreage and large machinery is not commonly in use.

Discussion of Machines in Use:

The machinery in use on the Red Plains Soil Erosion Experiment Station does not consist of any unusual number of different machines or of exceptionally large equipment. The principle has been to use equipment commonly found in this territory with a view to improvement for efficient operation over terraced land.

Vulcan Three Bottom Plow:

Much of the plowing on the station farm is done with a vulcan

three bottom 16 inch plow equipped with a tractor hitch. Only two bottoms are used due to lack of sufficient power to handle all three. This machine is subject to no major disadvantages when used on terraced land so long as operations are conducted paralled to the terrace ridge. By proper arrangement of the plow strips the moldboards may be made to throw the dirt up to the peak of the terrace ridge from each side, thus building up the terrace with each plowing operation. It is practically impossible to use a machine of this type across the terrace because the shares dig deep into the ridge top resulting in serious decrease of effective height. At the point where plow strips join between terraces an unsightly deadfurrow is often created due to the variation in distance between terraces with slope of land. At points where this width suddenly increases, this deadfurrow will branch into two lines with a back-furrow between. If these furrows are not properly harrowed down they will conduct water from a considerable distance before allowing it to break into the main terrace channel. This concentration results in gully erosion between terraces.

Suggestions for improvement are included in the following statements:

1. The frog of the plow is too long on the model in use in Guthrie, shortening the life of shares, and making them difficult to force into the ground.

2. The plow is not adopted to short turning with a tread type tractor.

<u>Oliver Single Bottom Plow</u>:

This plow is not used a great deal on the Guthrie station

because it is not adpated to operation over terraced land. The one wheel gage employed on this type of plow does not prevent side slippage and therefore the utility of the plow is practically destroyed. A plow with three wheels to gage and prevent slippage is much more efficient in operation.

Wheatland One-Way Disc Plow:

The remainder of the plowing on the station farm is accomplished with a Wheatland One-Way Disc plow equipped with 26 inch discs (Figure 23). This machine can cover a larger area in a given time than the moldboard, plow, but will not plow to as great a depth. When the implement is used in normal plowing operations, on plow strips so arranged that the dirt will be thrown to the terrace ridge, a gain in terrace height of approximately six inches is usually apparent. By making additional rounds on the terrace ridge this increase in height will be made larger. When the disc plow is run directly across a solid terrace ridge, no great damage is done, but when the ridge is crossed at an angle, as in Figure 23, the total weight of the machine is concentrated on the center discs and a distinct lowering of the terrace results. It is most advisable to use the implement in operations parallel to the terrace ridge. Observation has also proven that it is not desirable to use a machine of this type in ground containing solid, well anchored roots. The thin edges of the disc cut into the root and bind, due to being set at an angle with the direction of pull. The forward motion of the machine creates a torque between the root and the disc which is often relieved by the tearing of the disc edge.

A one-way disc plow equipped with 23 inch discs, and loaned to the station through the courtesy of the Case Manufacturing Company, will

because it is not adapted to operation over terraced land. The one wheel gage equipped on this type of plow does not prevent this sideways end move- ment the utility of the plow is considerably decreased. A plow with three wheels to gage and prevent slippage is much more efficient in operation.

<u>Wheatland One-Way Disc Plow</u>:

The remainder of the plowing on the station farm is accom- plished with a Wheatland One-Way Disc plow equipped with 12 inch discs (Figure 42). This machine can cover a larger area in a given time than the moldboard plow, and will not plow up as great a ridge. When the implement is used in normal plowing operations, on plow strips or terraced land the disc will be thrown to the terrace ridge, a gain in terrace height of approx- imately six inches is usually apparent. By making additional rounds on the terrace ridge this increase in height will be much larger. When the plow is run directly across a solid terrace ridge, no great damage is done, but when the ridge is crossed at an angle, as in Figure 43, the total weight of the machine is concentrated on the cutting discs and a constant cutting of the terrace results. It is very advisable to use the implement in operations parallel to the terrace ridge. Observation has also proven that it is not desirable to use a machine of this type in ground containing roots, such as buried roots. The thin edges of the disc cut into the root and bind, due to being set at an angle with the direction of pull. The forward motion of the machine creates a torque between the root and the disc which is often followed by the tearing of the disc edge.

A one-way disc plow equipped with 23 inch discs, and loaned to the station through the courtesy of the [illegible] Company, will

be tried out on terrace construction and maintenance and on field plowing during the year 1933. The diameter, radius of convexity of the discs, and spacing of discs offer the main possibilities for change in design of this type machine.

Tandem Disc and Spike Tooth Harrow:

For the preparation of seed bed an the station farm, the tandem disc, with 14 inch diameter discs, two five foot sections of spike tooth harrow, or the two in combination, are used (Figure 24).

The tandem disc is highly satisfactory for use on terraced land due to the implement being constructed in four sections of seven discs each. These sections are all connected in a manner sufficiently flexible to allow the machine to conform to the outline of terrace channel or ridge. The two section harrow has a similar degree of flexibility which may be further increased by placing a horizontal hinge in the center of the solid wooden evener shown in Figure 24. Even these machines should not be pulled with one section directly on the terrace ridge because of the resultant lowering of the terrace ridge (Figure 24). The same action results when the implements are pulled directly across the ridge instead of parallel to it.

John Deere Two Row Planter:

This machine was designed for use with a two horse team but is frequently used with a tractor on this station. Best results are obtained with the team.

The planter cannot readily be adjusted to prevent planting too deep in crossing the terraces. The machine has a tendency to slip down hill

when working on the side slope of the terrace ridges and as a result, the wheels do not follow in line with the runner openers and drop planters. Poor covering of the seed results. All makes of planters with this general design are subject to the same faults.

Suggestions for improvement of this planter for use on terraced land are:

1. The use of small diameter split wheels, at some sacrifice of light draft, placed at the absolute minimum distance from the drop planters might insure satisfactory coverage.

2. A leaning wheel adjustment which would permit simple change by the operator to counteract the effect of thrust on steep slopes.

3. Some means of shifting the planter on a sliding axle might be arranged to that at any time the wheels could be shifted into line behind the drop planters for proper coverage.

Moline Grain Drill:

A Moline nine foot grain drill with power lift is used in the planting of all grain crops. The length of the machine is such that when working over the terrace channel or on the side of the terrace ridge, the drills over the low part of the channel will not touch the ground, while those over the higher parts of the ridge will place the grain at too great a depth. When crossing the terrace the drills drive deep into the ridge with a resultant double damage in that the ridge top is lowered and the grain is planted too deep.

These faults might be corrected by dividing the long rigid drill section into rigid units of three or four foot length connected together in a flexible manner.

Moline One Row Cultivator:

This machine is a standard wheel guide cultivator with two gangs of three shovels each and foot and hand controls for moving each gang in horizontal and vertical planes. The main fault with the machine lies in its tendency to creep down hill when working on the steep slopes encountered on the terrace ridge. This creepage causes the machine to work in a continual skew, throwing the wheels at a slight angle with the direction of the row. As a result it is difficult to properly control the location of the shovel gangs and plants are often covered or cut out. The wheels when turning in a skew will pick up dirt like a disc blade and cover young plants.

There is no simple method for adjusting the elevation of the different shovels in each gang, independently of the gang elevation. On the sideslopes of the terrace ridge the front shovel of the gang may be buried at the same time the rear shovel is barely touching the ground. This unequal penetration produces poor cultivation of the soil and leaves many weeds.

Suggested remedies for these faults are:

1. Thin fins on the wheels that will penetrate the soil and prohibit side slippage.

2. Some method of leaning wheel adjustment which could be readily made by the operator to balance the side slippage on various slopes.

3. A method of tilting each shovel gang in the plane of

the wheel axles would insure even penetration of the shovels. This adjustment might also be made by raising and lowering each shovel individually.

Do-All Tractor Cultivator:

The Do-All general purpose tractor may be converted into a two row cultivator by removing the tractor front wheels and placing the cultivator attachment behind the drive wheels. Wherever possible this machine was used in the cultivation of crops. It was found that it was almost impossible to cultivate the top row on the terrace with the two-row cultivator since the wide distance between the wheels permitted the cultivator to dig in too deep and this could not be regulated (Figure 25). It was necessary to use a one-row horse cultivator for this purpose. It was found also that it was very difficult to use the two-row Do-All cultivator on the lower side of the terrace which was steeper than the upper side, (Figure 26). There was a tendency for the rear wheels of the Do-All tractor to slip down the slope which made it difficult to follow the row satisfactorily.

The second year no rows were planted on top of the terraces and it was found that the two-row Do-All cultivator could be used quite satisfactorily on the upper side of most of the terraces, but could not be used successfully on the lower and steeper side of the terraces with 20 to 25 feet base width. It was also found that a two-row cultivator could be used satisfactorily in crossing the terraces 25 to 30 feet wide at an angle of about 45°, but for smaller angles the same difficulty was encountered as in attempting to cultivate a row on the top of the terrace. Two outstanding criticisms of the tractor cultivator are the lack of self stabilization, which results in a tendency to creep when working on the side of a terrace, and lack of

the wheel axles would insure even penetration of the shovels. This adjust-
ment might also be made by setting the [illegible].

<u>Do-All Tractor Cultivator</u>

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Figure 25: Do-All tractor cultivator on top of Terrace 5-B cultivating row on each side of ridge top. Outer shovels are out of ground. June 18, 1931.

Figure 26: Do-All tractor working parallel to Terrace 5-B on lower side of terrace. Skew is so great that tractor wheel must rest on crop row to prevent plowing out crop of beans. June 18, 1931.

flexibility in both the longitudinal and lateral planes of the cultivator. The tendency to creep or slip down the slope often results in plowing out or covering the crop. Lack of the proper flexibility is responsible for the shovels digging in excessively deep when crossing a terrace, (Figure 27), which often results in plowing out or covering the crop on top of the terrace. Less digging occurs where the location of the cultivator gangs is such that they rise and fall with the wheels of the tractor in crossing a terrace. It seems that depth of plowing might be satisfactorily regulated by the use of gage wheels at each gang of sufficient size and width to lift the gangs in loose soil conditions. It is believed that a satisfactory degree of stabilization and flexibility could readily be obtained by simple changes in design which are necessary if the tractor cultivator is to play a prominent part in the farming of the rapidly expanding area of terraced land.

Grain Binder:

Twelve acres of oats on Terraces 3-C to 6-C were cut in 1931 with a seven foot binder drawn by a Caterpillar 15 tractor. (Figures 28 and 29). Observations made led to the following criticisms and suggestions:

1. The space between bull wheel and grain wheel is so great that the platform jams against the top of the terrace ridge when the wheels are run on opposite sides of the ridge top. When the machine is run with these wheels on opposite sides of the terrace channel the cutter bar cuts above or into the heads of the grain in the channel. (Figure 28).

Flexibility is both the [illegible].
The tendency to creep or slip down the slope often results in plowing out or covering the crop. [illegible] shovels digging in excessively deep when crossing a terrace, (Figure 27), which often results in plowing out or covering the crop on top of the terrace. Less digging occurs where the location of the cultivator gangs is such that they [illegible] terrace. It seems that [illegible] the use of gage wheels [illegible] gangs in loose soil conditions. It is believed that a satisfactory degree of stabilization and flexibility could readily be obtained by simple changes in design which are necessary [illegible] part in the farming of the rapidly expanding area of terraced land.

<u>Grain Binder:</u>

Twelve acres of oats on terraces 7-C to 6-C were cut in 1931 with a seven foot binder drawn by a Caterpillar 15 tractor. (Figures 28 and 29). Observations made led to the following criticisms and suggestions:

1. The space between bull wheel and grain wheel is so great that [illegible] the wheels are run on opposite sides of the ridge top. When the machine is run with these wheels on opposite sides of the terrace channel the cutter bar cuts above or into the heads of the grain in the channel. (Figure 30).

Figure 27: Do-All tractor cultivator crossing Terrace 5-B at right angle. Tractor wheels are just over ridge top. Beam is resting on ground and front cultivator shovels are buried. June 18, 1931.

Figure 28: Seven foot binder cutting oats in Channel of terrace 3-C. Note height of cutter above channel.

2. When crossing perpendicular to the ridge of a terrace of moderate cross section, the cutter bar cuts directly into the top of the terrace ridge, (Figure 29). This was caused by lack of sufficient adjustment for tilt from front to rear.

3. When cutting on the side of a terrace of moderate cross
4 section, the bundle carrier will nose into the upper side of the channel, forcing the carrier back and resulting in failure to dump when tripped.

4. Difficulties with present machines lessen as the width of terrace is increased or as the length of cutter bar is decreased.

5. A push binder of six to eight foot cutter bar, with all mechanism placed behind the bar, would apparently work very well on the terraces at the station farm. Such a binder might be constructed to fit around the front end of a farm tractor.

6. The ordinary pull binder might be adapted to use on terraces by introducing the following adjustment for greater flexibility:

(a) a method should be devised whereby the machine can be tilted from front to rear and vice versa when crossing terraces.

(b) larger wheels and a proper regulating system to give a large range of vertical movement for the whole machine would be of value when working the top of the terrace ridges.

(c) a flexible horizontal connection between the binding mechanism and the cutter bar and

Figure 29: Caterpillar 15 Tractor and seven foot binder crossing at right angle to terrace ridge. Note that cutter is striking ridge top.

conveyor platform will allow the machine to conform to the shape of the channel or ridge top.

Tractors:

Two wheel type tractors, the Rumely Do-All General Purpose and the John Deers Model D 15:27 horsepower are owned by the Red Plains Soil Erosion Experiment Station. A caterpillar 15 horsepower tracklaying type machine was loaned to the station from July, 1930, to January, 1933.

It was found from the standpoint of traction particularly in crossing the comparatively loose soil in the tops of the terraces that the tracklaying type tractor had considerable advantage over the wheel type. The wheel tractor can not readily cross the terraces with the same load that it can easily handle between the terraces and much time is lost due to digging in and stalling in crossing a terrace, also resulting in considerable injury to the terrace. Also when working parallel to and on the side slope of a terrace embankment, the tracklaying tractor does not tend to slip down the slope as is the case for the wheel tractor. About the only disadvantage of the track laying tractor is the shock received by the tractor and operator when the tractor moves up one side of a terrace and drops down on the other wide.

Miscellaneous Machines:

A Corsicana stalk cutter and a John Deere stalk cutter are used in all fields and are at no disadvantage on the terrace ridges. A McCormick-Deering Mower is used for cutting all hay crops and does satisfactory work in terraces by proper operation.

Conclusions:

From these observations it is apparent the major objection to existing farm implements when applied to terraced land are lack of self stabilization on steep slopes, lack of flexibility to accomodate sudden changes in surface, and impossibility of quick and ready adjustment.

It is impossible to build terraces to fit the requirements of all present farm machinery, therefore, it will be necessary to redesign some of these machines to conform to the requirements of terrace embankments found most satisfactory for each locality.

E X P E R I M E N T No. 9.

Building up Badley Eroded Land with Terraces, Green Manure, Cover Crops, and Fertilizers.

In this experiment an attempt is made to reclaim severely eroded and gullied land by preventing further erosion through the application of terraces, cover crops, and gully chekks, and then improving the soil by the application of green manure crops and fertilizers. Plots 1 to 12 inclusive, located on Terraces 5-B to 9-B (Figure 1), comprise the layout.

The area used for this experiment was so severely eroded that it had been abandoned for agricultural use at the time this station was founded. The gullies were first reclaimed by small check dams of various types and terraces were then constructed. Data on this phase of the work is given under Experiment No. 10.

In 1929 and 1930, terraces 5-B to 9-B, were divided into Plot B, and Plots E-1, to E-6. The different plots in the order named were planted to mung beans, soy beans, sudan grass, cotton, sweetclover, cane and cowpeas in the year 1929. All crops except cotton were plowed under for green manure. The yield of cotton on plot E-3 was 89.0 pounds of lint cotton per acre. During the year 1930, all the plots were planted to cotton with yields as shown in Table 8. In the year 1931, the area was divided into the twelve smaller plots with a crop rotation scheme as layed out in Table 9. The agronomic features are under the supervision of the

Record of Crop Yields on Plots Located on [illegible]
Red Plains Soil Erosion Experiment Station Near Guthrie, Oklahoma

Plot Number	Treatment of Crop	Division	Pounds of Seed Cotton per Acre for Crop Yield: 1929	1930	1931	1932	Remarks.
B-1			Mung beans	425.7			These plots were changed to plots 1 to 12 in 1931.
E-1			Soy beans	223.5			
E-2			Sudan grass	197.5			
E-3			287	259.0			
E-4			Sweet clover	302.4			
E-5			Cane	317.0			
E-6			Cowpeas	350.6			
1	Cotton and Mung beans in alternate years				Mung beans	356.8	Mung beans and soy beans on Plots 1 and 2 turned under for soil improvement in 1929 & 1931
2	Cotton and Soybeans alternated				Soy beans	286.5	
3	Cotton-no cover, no fertilizer	Limed			608.0	434.4	
		Unlimed			384.4	350.7	
4	Cotton - Rye cover crop, 300 lbs. per acre of 4-12-4	Limed			806.9	706.9	
		Unlimed			653.9	537.1	
5	Cotton - no cover crop - 300 lbs. per acre of 4-12-4	Limed			616.1	590.8	
		Unlimed			505.3	528.0	
6	Cotton - Rye cover crop - no fertilizer	Limed			328.8	183.2	
		Unlimed			188.9	130.9	
7	Cotton - no cover crop or fertilizer	Limed			371.5	228.8	
		Unlimed			280.1	159.0	
8	Sweet clover alternating with cotton - limed and 100 pounds superphosphate per acre.	Limed			Sweet clover	Sweet clover	Sweet clover raised in 1931 and 1932
		Unlimed			Sweet clover	Sweet clover	Terraces 8 and 9 limed at the rate of one ton of ground stone per acre 1931, 1934 and 1937.
9	Cotton - winter legume cover crop - vetch	Limed			411.6	341.2	
		Unlimed			545.7	472.6	
10	Cotton-Vetch winter cover crop: Cotton treated 300 lbs. 0-12-4 fertilizer per acre	Limed			655.3	508.6	
		Unlimed			667.6	662.0	
11	Cotton-Vetch winter cover crop: Cotton treated 300 lbs. 0-12-4 fertilizer per acre	Limed			580.1	441.7	
		Unlimed			850.2	701.8	
12	Cotton - Check - no treatment.	Limed			419.4	233.0	
		Unlimed			714.9	382.2	

Table No. 8

57a

Record of Crop Rotations and Cover Crops
Red Plains Soil Erosion Experiment Station Near Guthrie, Oklahoma.

Plot	Treatment of Crop	1931	1932	1933	1934	1935	1936	1937	1938
1.	Cotton and Mung beans in alternate years	Mung beans	Cotton	Mung beans	Cotton	Mung beans	Cotton	Mung beans	Cotton
2.	Cotton and Soybeans alternated	Soybeans	Cotton	Soybeans	Cotton	Soybeans	Cotton	Soybeans	Cotton
3.	Cotton-no cover, no fertilizer	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
4.	Cotton - Rye cover crop, 300 lbs. per acre of 4-12-4.	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
5.	Cotton - no cover crop - 300 lbs. per acre of 4-12-4.	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
6.	Cotton - Rye cover crop - no fertilizer	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
7.	Cotton - no cover crop or fertilizer	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
8.	Sweet clover alternating with cotton - limed and 100 pounds superphosphate per acre.	Sweet clover limed	Sweet clover	Sweet clover	Cotton	Sweet clover limed	Cotton	Sweet clover limed	Cotton
9.	Cotton - winter legume cover crop - vetch	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
10.	Cotton-Vetch winter cover crop: Cotton treated 300 lbs. 0-12-4	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
11.	Cotton-Vetch winter cover crop: Cotton treated 300 lbs. 4-12-4 fertilizer per acre.	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
12.	Cotton - Check - no treatment.	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
13.	Cotton and cowpeas alternated. Unterraced field.	Cowpeas	Cotton	Cowpeas	Cotton	Cowpeas	Cotton	Cowpeas	Cotton
14.	Cotton and cowpeas alternated. 100 ft. closed level terraces	Cowpeas	Cotton	Cowpeas	Cotton	Cowpeas	Cotton	Cowpeas	Cotton
15.	Cotton and cowpeas alternated. Level open-end terraces.	Cowpeas	Cotton	Cowpeas	Cotton	Cowpeas	Cotton	Cowpeas	Cotton

3 - 7 Lower two terraces limed at the rate of 1 ton of ground stone per acre 1931, 1934 and 1937.
9 - 12

Table No. 9

#1

Bureau of Chemistry and Soils. Cotton yields for the years 1929 to 1932, inclusive, are listed in Table 8. The period of time covered by present data has not been sufficient to show a consistent trend toward increased crop yields.

Yields of seed cotton for terrace channel, terrace ridge, and interval area for the year 1931 and 1932, are shown in the following table. These yields represent weighted averages for each terrace and are not separated into the various plots:

YIELD OF SEED COTTON PER ACRE FOR CHANNEL, RIDGE, AND INTERVAL
Terraces 5-B to 9-B

	1931			1932		
Terrace	Ridge	Channel	Interval	Ridge	Channel	Interval
5-B	692.1	463.6	394.7	560.8	181.8	176.8
6-B	663.1	562.8	464.6	521.6	438.4	385.8
7-B	628.1	495.1	467.2	565.4	262.1	399.1
8-B	633.4	557.2	481.3	604.6	375.6	402.2
9-B	617.5	582.5	513.5	474.0	358.2	390.7

It is interesting to note that for both these years the average yield of terrace ridge and channel, which represents the area disturbed in the terracing operation, is higher than the yield from the interval which was not dibturbed. The ridge and channel yields individually were higher than the interval yield in 1931, but in 1932 the channel yield was slightly below the interval yield. This was caused by ponds which formed at old gully

crossings in the channel and remained there during the long series of spring rains, thus drowning out much of the crop.

E X P E R I M E N T N o. 10.

Filling in and Checking Erosion in Gullies and Preventing Erosion of Terrace Outlets.

Experiments were conducted to determine the best methods, most suitable materials, and costs for the construction of devices to check erosion and cause filling of the numerous gullies found on the erosion station farm at the start of experimental work. Soil saving and check dams were built in these gullies with different materials such as brush, poles and old woven wire, all of which were available on the farm. Different methods of construction were employed and the dams were built with different widths, heights, and spacings along the gully lines.

<u>Construction and Cost of Check Dams:</u>

Sixty-one check dams were built with brush, poles, and rock in the gullies on the Guthrie farm; of this number 6 were loose brush dams, 35 were anchored bmush dams, 6 were pole dames and 14 were rock dams. The length of the dams is taken as extending along the gully and the width as across the gully. This is contrary to the usual practice for dams built across large streams.

Ordinarily the cost of constructing such dams on a farm will depend largely on the availability of material and the distance that/is it hauled. Where brush is cut especially for the construction of dams, the cost of the dams would be greater than where the cost of cutting and hauling

brush could be charged to clearing the land. The labor of cutting and part of the hauling was not charged to ~~clearing~~ the cost of dams but was charged to the clearing of the land on the Guthrie farm. Such things should be taken into consideration by the farmer in estimating the cost of building check dams on his farm.

In Table 10, are given the average dimensions and cost of the different kinds of dams built. The average dimentions of the loose brush dams are 15 feet long, 4.1 feet wide, 2 feet high, and the average cost was \$0.98. These were the cheapest dams built.

The average dimensions of 10 stake and brush dams are 23.2 feet long, 8.3 feet wide, 3.0 feet high, and the average cost was \$11.87. The brush was carefully placed in these dams and the bottom of the gullies was covered with dry cane stalks.

Eighteen small pole and brush dams were built with average dimensions of 13.6 feet long, 6.4 feet wide, and 1.5 feet high, the average cost being \$4.16. Three dams were anchored with wire fastened to stakes driven into the bottom and sides of the gully, and the others were anchored with cross poles fastened to stakes on the top of the banks.

No particular care was taken in placing the brush for the other seven small pole and brush dams, and large open places were left in the brush. This reduced the cost of the building considerably. The average dimensions of these dams are 9 feet long, 4.6 feet wide, 1.0 foot high, and the average cost was \$1.39. These dams were much cheaper to construct, but somewhat smaller than the 18 dams which were carefully built.

Summary Sheet of Cost and Construction Data - Brush, Pole, and Rock Check Dams
Red Plains Soil Erosion Experiment Station Near Guthrie, Oklahoma

Kind of Dam	No. of Dams	Average Dimensions of Dams: Length	Width	Height	Construction Data Average per Dam: Man Hours	Material	Total Cost	Remarks
Small loose brush	6	15.0	4.1	2.0	3.9	-	0.98	Loose brush thrown in gully with butts upstream. Gully filled half full. Rock placed on some of the dams.
Large stake and brush, brush carefully placed	10	23.2	8.3	3.0	46.2	0.32	11.87	Brush laid flat with butts upstream. Held by wire and stakes.
Small pole and brush, Brush carefully placed	18	13.6	6.4	1.5	16.3	0.10	4.16	Brush laid flat with butts upstream. Six were secured by wire and stakes and the remainder by crossed poles.
Small pole and brush. Brush not carefully placed. No fine material	7	9.0	4.6	1.0	5.1	0.12	1.39	Brush laid flat with butts upstream, and secured with poles in X shape across gully with ends staked down.
Small Rock	13	1.6	5.7	0.5	2.8	-	0.71	Rocks placed tightly with straw underneath and on upper side except for three in which the rocks were placed loosely.
Large Rock	1	3.5	6.7	2.0	11.0	-	2.75	Loose rock laid with straw between to make dam impervious
Pole Dams	6	1.55	8.4	1.6	14.08	0.65	4.17	Bottom layer of poles laid lengthwise in gully, extending below dam to form apron. Poles above laid crosswise extending into bank. Notch cut through top two layers. Poles held in place by spikes and wire.
Concrete Baffles	6	-	3.6	1.8	7.2	4.08	5.24	Concrete reinforced with hog wire. Average depth of notch = 0.8 feet. Width of notch is taken as width of dam.
Concrete Baffles	4	-	13.5	0.9	19.8	7.73	13.67	" " " " " "

The average length, width, height, and cost of six pole dams is given in Table 10. The average length is 1.55 feet, width 8.4 feet, height 1.6 feet, and the average cost $4.17.

Fourteen rock dams were built, thirteen of which were small rock dams ranging in depth from 6 inches to 9 inches. The building of these dams did not require much labor. The average dimensions are 1.6 feet long, 5.7 feet wide, 0.5 feet high, and the average cost was $0.71. One comparatively large rock dam was built. This dam is 3.5 feet long, 6.7 feet wide, 2.0 feet high, and cost $2.75. In building these rock dams,straw was placed among the rocks to prevent the silt from washing through the holes. Where this method was not employed, it was almost impossible to prevent silt from washing through the dam.

Some conclusions drawn from observation and experiments with check dams built in gullies on the Guthrie farm are shown below:

1. Low dams are more succesfful than hih dams since the water falls a shorter distance below the dam, and there is less tendency to erode the bottom of the gully. The pressure ~~ix~~ of water above high dams is sufficient to force out silt that has accumulated in the open spaces of the more porous dams. From the standpoint of both economy and successful operation, it is believed that a height of about 2 feet is the most satisfactory for check dams in small gullies.

2. The greater the flow of water in the gully the stronger should be the anchorage of the dam. The flow of water in the gully depends upon the size of the drainage area.

Brush dams without anchorage have not been found satisfactory. In small gullies with a very limited drainage area, some form of light anchorage such as a few loose rocks, should be placed on top of the brush.

3. The sides of the gully at the location of dams should be protected against washing to the top of the bank or at least as high as the water in the gully is expected to rise. The most common failure of check dams consists of erosion at one or both ends of the dam.

4. An apron~~g~~ should be built below impervious dams to prevent the falling water from eating back under the dam. This is also a very common ~~xxxxx~~ cause of failure of check dams.

5. For the best results, the top of one dam should be placed at the level of the bottom of the dam above. The results of the experiments showed that it would be possible to place the dams further apart than this since a ~~fill~~ fill occurred the total distance between the dams in Gullies F and G. However, it is believed that better results will be obtained where the rule is observed.

6. The check dams should not reduce the cross-section of the gully sufficiently to cause the water to overflow the banks, as this usually results in the erosion of a new parallel gully down the slope.

7. More rapid filling above a brush dam occurs where the bottom of the gully is covered with grass, straw or other similar material, the finer brush placed next to the straw, and the larger brush placed and packed so as to reduce open spaces in the brush to a minimum. This method tends to prevent erosion along the sides or bottom of the gully which results in washing out a hole and undermining the dam.

Life of Check Dams:

The rock dams constructed on this project have as yet shown no signs of deterioration. Time appears only to solidify this type of dam by adding a heavy blanket of silt, grass roots and the like.

The brush dams seem to have a useful life from two and one half to three years. In Figure 30 is shown a V-notch brush dam in Gully G that is practically disintegrated after three years service.

Pole dams are subject to fairly rapid decay, but on the average will last about one year longer than the brush dam and are more efficient in silt stopping ability. In Figure 31 is shown a pole dam in apparently good condition after three years of service, while in Figure 32 this same dam is shown as a complete failure after three months of additional service during which a series of heavy rains occurred.

Figure 33 is a view of a woven wire dam located in Ravine A. A substantial fill of silt, leaves, and branches has deposited behind the dam during three years of service. This type of dam is efficient and economical for depths of fill not exceeding three feet.

7. More rapid filling above a brush dam occurs where the bottom of the gully is [illegible] with grass, straw or other similar material, the finer brush placed next to the straw, and the larger brush placed and packed so as to reduce open spaces in the brush to a minimum. This method tends to prevent cutting along the sides or bottom of the gully which results in washing out a hole and undermining the dam.

Life of Check Dams

The rock dams constructed on this project have as yet shown no signs of deterioration. They [illegible] this type of dam by adding a heavy blanket of silt, [illegible].

The brush dams seem to have a useful life from two and one half to three years. In Figure [illegible] is shown a loose brush dam in [illegible] that is practically [illegible] after three years service.

Pole dams are subject to fairly rapid decay, but on the average will last about one year longer than the brush dam and are more efficient in silt catching ability. In Figure [illegible] is shown a pole dam in apparently good condition after three years of service, while in Figure [illegible] this same dam is shown as a complete failure after three months of additional service during which a series of heavy rains occurred.

Figure 33 is a view of a woven wire dam located in Ravine 1. A substantial fill of silt, [illegible], has deposited behind the dam during three years of service. This type of dam is efficient and economical for [illegible].

Figure 30: Brush dam at lower end of Gully G. Note how brush has rotted and fallen in after three years of service. April 8, 1932.

Figure 31: Pole dam after three years service, located at lower end of Gully F. Note that fill back of dam is level with notch. April 8, 1932.

Figure 32: Failure of pole dam at lower end of Gully F, This dam was installed in 1929. July 7, 1932.

Figure 33: Woven wire dam in Ravine A. Note the accumulation of silt behind the wire. April 8, 1932.

Soil Saving Dams:

An earth soil saving dam was constructed in Ravine B (Figure 1) during 1931, to aid in the reclamation of this ravine and to serve as a roadway to the plots in the southeast corner of the farm. The drainage area above this dam is about 1,300 feet in length and contains 12.5 acres of cultivated land. The crest length of the dame is 50 feet with a crest width of 12 feet. It is 10 feet high above the original bottom of the ravine. Discharge through the dam is handled by a corrugated iron culvert two feet in diameter and 32 feet long. This pipe is laid in the solid ground forming the original ravine bank rather than in the soft filled in dirt to prevent settlement and distortion. The centerline of the pipe at the upstream and is placed three feet below the crest of the dam and at the downstream end is placed about one foot above the ravine bottom. The effective head on the pipe is about eight feet with a two foot freeboard on the dam. Erosion at the outlet is prevented by a concrete though 10 feet long. Total cost of the dam including materials and labor was $138.74.

A mortared masonry soil saving dam was built in Ravine A during the year 1932. This dam, (see Figure 34), was laid with sound rock and cement mortar to a height of four feet above the gully bottom. The mortared rock extended into a trench cut two feet into the bottom and sides of the ravine. A masonry apron and stilling pool was built to form a pool six feet long measured from the toe of the dam and one foot deep. The masonry wall forming the dam is two feet thick at the bottom and one foot at

Figure 34: Rock dam laid with mortar to height of four feet in Ravine A. May 27, 1932.

the top. Earth, well tamped was filled in at a 2 to 1 slope behind the dam. The total cost including materials and labor was $25.00.

In connection with the construction and maintainance of this type of dam observation has shown that:

1. The dam must be sunk deeply into the ravine sides and bottom to cut off seepage.

2. The dam must be solidly constructed and mortared together closely to withstand large flows of water.

3. Wing walls must be built staunchly and of ample height to accomodate maximum flow.

4. A properly designed stilling pool must be provided below the dam to prevent erosion under the toe of the dam. The length of this pool should be at least one and one half times the height of the dam, and the depth should be about one fourth the height of the dam. These figures are based on observation of existing dams and not on hydraulic tests, therefore the figures are approximate.

5. A dam of rock laid carefully without mortar to a height of two feet in this same ravine failed under the first flow of any magnitude, proving that this type of construction will not withstand large flow such as comes from the 35 acres of land draining into the ravine.

Terrace Outlet Protection:

Terrace outlet protective devices were installed on terraces 5-B to 9-B during the year 1932. Three of these protective devices were

the top. Earth, well tamped was filled in at a 2 to 1 slope behind the dam. The total cost including materials and labor was $25.00.

In connection with the construction and maintenance of this type of dam observation has shown that:

1. The dam must be keyed deeply into the ravine sides and bottom to cut off seepage.

2. The logs must be solidly constructed and fastened together closely to withstand large flows of water.

3. Wing walls must be built staunchly and of ample height to accommodate maximum flow.

4. A properly designed spilling pool must be provided below the dam to prevent erosion under the toe of the dam. The length of this pool should be at least one and one half times the height of the dam, and the depth should be about one fourth the height of the dam. These figures are based on observation of existing dams and not on hydraulic tests, therefore the figures are approximate.

5. A dam of rock laid carefully without mortar to a height of two feet in this same ravine failed under the first flow of any magnitude, proving that this type of construction will not withstand large flow such as comes from the 35 acres of land draining into the ravine.

Terrace Outlet Protection:

Terrace outlet protective devices were installed on terraces 2-3 to 9-2 during the year 1933. Three of these protective devices were

constructed of poles (See Figure 35) on the same principle used in pole check dams. The other two devices were of rock as shown in Figure 36. These five structures all fulfilled their purpose with complete satisfaction during the heavy rains of 1932. There was no cost involved in securing material for these outlet protections since rock and poles were available on the farm. The labor used amounted to approximately six man hours for each device, including precurement of material and installation.

In building these units it was necessary to observe the following precautions to insure satisfactory results:

1. It was necessary to sink a trench to hard footing, usually one foot deep, and start the rock or pole construction on this base to prevent seepage and undercutting.

2. Straw or hay was forced into all crevices and placed in a sheet behind the device to insure the catching of silt.

3. Wing walls were built to ample height above the dam so that all water would pass over the crest of the structure and not around the ends.

At the outlets of terraces 7-E, 8-E, 9-E, and 10-E, two other types of protection were installed. One of these consisted of sheets of corrugated iron cut into short lengths such that when driven the maximum possible distance into the soil, the upper end of the sheet was at terrace grade. One sheet at each end was allowed to project one foot above terrace grade to serve as a wing-wall. The other type consisted of small straight stakes driven side by side in a line across the channel. The tops of the stakes in the center of the device were driven to terrace grades and several of those at each end of the line were driven to a point one foot above grade to serve as wing-walls.

construction of poles (see figure [illegible]) on the same principle used in pole check dams. The other two devices were of rock as shown in figure [illegible]. These five structures all fulfilled their purposes with complete satisfaction during the heavy rains of [illegible]. There was no cost involved in making material for these outlet protections since rock and poles were available on the farm. The labor cost amounted to approximately [illegible] for each device, including procurement of material and installation.

In building these walls it was necessary to observe the following precautions to insure satisfactory results:

1. It was necessary to sink a trench to hard footing, usually one foot deep, and start the rock or pole construction on this base to prevent seepage and undermining.

2. Straw or hay was forced into all crevices and placed in a sheet behind the device to insure the catching of silt.

3. Wing walls were built to ample height above the dam so that all water would pass over the crest of the structure and not around the ends.

At the outlets of terraces 7-E, 8-E, 9-E, and 10-E, two other types of protection were installed. One of these consisted of sheets of corrugated iron cut into short lengths each that were driven the maximum possible distance into the soil. The upper end of the sheet was at terrace grade. One sheet at each end was allowed to project one foot above terrace grade to serve as a wing-wall. The other type consisted of small straight stakes driven side by side in a line across the channel. The tops of the stakes in the center of the series were driven to terrace grade and several of those at each end of the line were driven to a point one foot above grade to serve as wing-walls.

Figure 35: Terrace outlet protective device with wide notch constructed of pyramided poles at outlet of Terrace 8-B. Filling occurred during spring of 1932. October 10, 1932.

Figure 36: Terrace outlet protective device constructed of loose rock chinked with straw, at end of Terrace 6-B. All filling occurred during spring of 1932. October 10, 1932.

The corrugated roofing was more expensive since it involved the purchase of material in addition to labor of installation. Cost of material was $0.80 for each unit in addition to four more hours labor. For the devices using stakes, the material was secured on the farm, and eight man hours labor were required to secure, prepare, and rive the stakes for each unit.

Ditch Protection:

The ditch which drains all terraces in Plot 15-A was thoroughly protected against erosion by creosoted plank baffles installed in the year 1932. Each baffle had a crest length of six feet with wing-walls one foot high above the crest and fastened to the mainboard at a 45 degree angle. The only protection made against undercutting of the baffles consisted of setting the bottom of each baffle slightly below the crest of the baffle downstream. The cost of material for each baffle was $1.50 for ten linear feet of 3" X 12" creosoted bridge lumber. Two man hours labor were needed for each installation. It was found necessary when refilling the trench in which the plank baffles were set to mix some straw with the earth backfill and to tamp the fill thoroughly. This prevented the filled in dirt from washing out. These baffles all gave excellent results during the rains of 1932.

Creosoted lumber checks were also installed in the ditch which drains the B terraces into Ravine A. This ditch is a flat bottomed ditch 14 feet wide in the bottom and two feet deep. Baffles were constructed of one creosoted plank 2" X 12" X 16'-0" with win-walls of the same material fastened

at a 45° angle on each end. The same method of installation was followed as that used in the Plot 15-A ditch. Cost of material for each baffle consisted of $2.40 for 24 feet of creosoted 2" X 12" plank. Three man hours labor were required for the installation of each baffle.

An attempt was made to prevent erosion in the ditch draining the terraces in Field C by the use of rock checks laid without mortar. The checks were built of large rock laid carefully without mortar and chinked with straw. Only one of the checks was over two feet in height and the crest of each was level with the base of the check just upstream. These checks were filled level with silt after the first large runoff and effectively prevented erosion of the channel. It was noted, however, that the largest storms caused excessive flows of water which loosened the rock in several of the dams. If not carefully maintained, after each storm, it is probably that this type of structure would soon be destroyed.

From this date it appears that checks to prevent erosion ~~is~~ in terrace outlet ditches must be built in an integral unit to withstand the large flow of water.

at a 45° angle on each end. The [illegible] as that used in the Plot 15-A ditch. Cost of material for each baffle consisted of $1.40 for 24 feet of creosoted 2" X 12" plank. Three man hours labor were required for the installation of each baffle.

An attempt was made to prevent erosion in the ditch draining the [illegible] in Field C by the use of rock checks laid without mortar. The checks were built of large rock laid carefully without mortar and chinked with stones. Only one of the checks was over two feet in height and the crest of each was level with the base of the check just upstream. These checks were filled level with silt after the first large runoff and effectively prevented erosion of the channel. It was noted, however, that [illegible] caused excessive flows of water which loosened the rock in several of the dams. If not currently maintained, after each storm, it is probable that this type of structure would soon be destroyed.

From these data it appears that checks or [illegible] diversion ditches must be built in an integral unit to withstand the large flow of water.

E X P E R I M E N T No. 11.

Soil Movement Down the Slopes

Lines are laid perpendicular to the contours in several locations on the station farm (Figure 1) to determine the rate of soil movement down the slopes of unterraced land, level terraced, land, and graded terraced land. Permanent concrete bench marks are set at the upper and lower ends of each line.

Accurate measurements are made each year to determine the elevation of points along these lines at intervals of one foot, with the soil in practically the same condition as to physical characteristics. The effectiveness is measured by the extent to which this soil movement is retarded and a comparison of the profiles along these lines affords information on this subject.

It is thought that information obtained from these experiments will not be of value before a period of five years has elapsed and that the longer the experiment is continued, the more valuable will be the results obtained.

E X P E R I M E N T N O. 12.

Runoff from Small Watersheds with Different Characteristics

Measurements of runoff and soil loss are made on small watersheds with different conditions of cover and cultivation.

The following small watersheds comprise this experiment:

(1) A wooded watershed containing 5.62 acres indicated on the map as Plot 1.

(2) A badly gullied and eroded watershed containing an area of about 5.28 acres is designated as Plot J. This is an abandoned area, formerly cultivated, now covered with a growth of wild grasses and weeds.

(3) A level terraced watershed, consisting of the area between Terraces 1-R and 5-E and designated as Plot 15-A on the map, contains an area of 3.13 acres.

(4) A cultivated watershed, with rows running across the slope, contains an area of 3.61 acres and is designated as Plot 13 on the map. After the fall rains in 1932, terraces 5-B and 1-E were connected across the upper part of Plot 13 to prevent possible entrance of outside drainage waters. This reduced the area to 3.23 acres.

(5) In the summer of 1932 it was decided to include level terrace 6-E in this series of plots so that the runoff and soil losses from this terrace could be compared with those from unterraced Plot 13. This terrace is 620 feet long, has an

EXPERIMENT NO. 12.

[illegible]

Measurements of runoff and soil loss are made on small watersheds with different conditions of cover and cultivation.

[illegible]

(1) [illegible]

on the map as Plot 1.

(2) [illegible]

[illegible] an abandoned area, formerly cultivated, now covered with a [illegible] grasses and weeds.

(3) A level terraced watershed, consisting of the area between Terraces 1-E and 5-E and designated as Plot 15-A on the map, contains an area of 3.13 acres.

(4) [illegible] Plot 11 on the map. [illegible] and 1-E were connected across the upper part of Plot 13 to prevent possible entrance of [illegible] the area to [illegible] acres.

(5) In the summer of 1952 it was decided to include level terrace 6-E in this series of plots so that the runoff and soil losses from this terrace could be compared with those from unterraced Plot 13. This terrace is 650 feet long, has an

average vertical interval of 4.0 feet, and has a drainage area of 1.30 acres on land with an average slope of 4.56 per cent.

(6) An area having a close cover of native grass and small shrubs, with absolutely no gullies or bare spots was selected on the East Farm of the Erosion Station at the time 6-E was opened. This plot has an area of 2.50 acres with an average land slope of 5.9 per cent.

Parshall measuring flumes, automatic water level recorders, and Ramser silt sampling units are installed on all these watersheds except Plot J, which doesnot have a silt sampling unit.

Percentages of rainfall which appeared as runoff, and soil losses in tons per acre from these plots for the year 1931 are listed in Table 13, and for the year 1932 in Table 14.

<u>Losses for year</u>--<u>Plot L</u>.

For the year 1931, only 0.76 per cent of the rainfall ran off from Plot L with a cover of woods and brush. In 1932, due to increased rainfall, this figure was 2.0 per cent. The total runoff for the two years of record on this plot was only five per cent of that on Plot 13, the cultivated, unterraced watershed. The low water loss for the wooded area is due probably to the increased absorptive capacity of the soil rather than to the small storage capacity of the forest litter. The runoff water contains little silt and as a result the tiny pores of the soil are not clogged by deposits from the percolating water. As long as pores are open percolation will continue and the soil will absorb more moisture. Some storage also

results through the interception of the rainwater by leaves and branches of trees and brush. Most of this is probably soon lost through evaporation.

Soil loss per acre on this wooded plot was 0.03 tons in1931, and 0.18 tons in 1932. The total loss for the two years on Plot 13, the cultivated, unterraced watershed, was 429 times the amount lost during the same period from Plot L. The small amount of runoff from this plot, all at low intensities, cannot cause any serious erosion. The cover of litter on the soil prevents the water from attaining sufficient velocity to have any cutting power and strains many of the particles of soil that are in the water.

Losses for Year--Plot J.

Measurements of runoff only are made from Plot J. During 1931 this eroded and gullied area of native sod lost 11.2 per cent of the year's rainfall as runoff, and in 1932, the loss was 10.1 per cent.

Runoff percentages for Plot J show the effect of the many gullies which cut the sod cover in this area. These collect the runoff water and concentrate it at the outlet of the area in a more flashy manner than would be the case with an uneroded, grassed area. This area is not typical of bare, eroded fields such as Plot 13 because of the tendency for surface storage in the grass cover. Observation has shown that during the winter months freezing causes serious spalling of the gully banks, thus depositing large amounts of soil in the gully bottoms. During the spring rains the intense flows down the gullies carry out these deposits. These flows also undercut the banks at bends and cause large chunks to fall down

and becarried off by the flow in the gully channel. Further enlargement of the gullies is effected by the small rivulets of water which drop over the banks during periods of runoff. As the gullied area enlarges, the area covered with sod decreases and the runoff percentages must increase, creating higher rates of runoff and erosion from year to year. From these observations, it is evident that the most economical time to begin gully control is in the incipient state of formation.

<u>Losses for Year--Plot 15-A</u>:-

Only 19.7 per cent of the rainfall on level terraced Plot 15-A appeared as runoff during the year 1931, and for 1932, the percentage was 19.8. It is surprising that the figures should be so nearly identical for such different types of rainfall years. The percent of rainfall for each year which appeared as runoff is considerably below that of unterraced Plot 13, and in 1932 the percentage figure on Plot 15-A was less than two thirds of the value on Plot 13, and stands in about the same ratio to graded terraces 2-B and 3-B. It is believed that this difference is due to increased absorption of moisture on the level terraced area, but more data is needed before a definite conclusion can be drawn. That this moisture is of no benefit to crops is shown by the fact that for all years of record the yield on Plot 15-A has been much lower than on Plot 13. This is due to the drowning of much of the crop in the terrace channels.

Soil loss from Plot 15-A was at the rate of 7.57 tons per acre in 1931, and 15.70 tons per acre in 1932. These figures are high due to erosion in the channel of the ditch which drains the five terraces, and due to

and [illegible] by the flow in the [illegible]. Further enlargement
of the [illegible]
the banks during periods of runoff. As the gullied area enlarges, the
[illegible]
creating higher rates of runoff and erosion from year to year. From these
observations, it is evident that [illegible]
control is in the incipient state of formation.

[illegible]

Only 19.7 per cent of the rainfall on level terraced Plot
[illegible]
[illegible]
for each different type of rainfall [illegible]
[illegible]
[illegible]
third of the value on Plot 13, and stands in about the same ratio to graded
[illegible]
absorption of moisture on the level terraced area, but more data is needed
[illegible]
is wrong is shown by the fact that for all years of record the yield on Plot
[illegible]
much of the crop in the terrace channels.

[illegible]
[illegible]
[illegible]

deposits in the ditch of windblown sand which are in turn carried to the measuring unit. The ditch is now fully protected by plank baffles with grass planted between, and should give more accurate results during the year 1933.

Losses for Year. Plot 13:-

The per cent of rainfall during 1931 was 22.70 per cent on Plot 13, and in 1932, due to increased rainfall, this figure was 30.8 per cent. These percentages are practically the same as those for graded terraces 2-B and 3-B for the same years. The soil lost during the year 1931 was 43.9 tons per acre and during the year 1932 this figure increased to 88.1 tons per acre or a total of 132 tons per acre for the two years. Soil loss from long graded terraced 2-B, cropped in a somewhat similar manner and located on the same eroded slope was 14.99 tons per acre for the two years of record. The unterraced area thus lost 8.8 times as much soil as the long graded terrace due to the unrestrained flow and consequent high intensities of runoff on the unterraced area. The soil loss from Plot 13 for the two years of record was 12.5 times as large as that from terrace 4-B which is 1,500 feet long and has a constant grade of 4"/100 feet.

Losses for Year. Terrace 6-E and Pasture Area:-

These two runoff areas were both installed after the first half of the year 1932 and results are available only for the fall rains. There was absolutely no runoff from the pasture area during any of the storms due to the close cover of native grass and small shrubs which had not been pastured. Results from terrace 6-E are discussed under individual storm measurements.

deposits in the ditch of windblown sand which are in turn carried to the measuring unit. The ditch is now fully protected by plank baffles with [illegible]

[illegible]

[illegible] tons per acre or a total of 132 tons per acre for the two years. Soil [illegible] the unterraced area. The soil loss from Plot [illegible] for the two [illegible] was 12.6 times as large as that from terrace 4-E which is 1,[illegible] feet long and has a constant grade of 4"/100 feet.

Losses for [illegible], Terrace 6-E and Pasture Area:-

These two runoff areas were [illegible] after the first half of the year [illegible] and records are available only for the fall rains. [illegible]

Runoff and Soil Losses by Storms, 1932:-

Measurements of rainfall, runoff, and soil losses, on the terraces comprising this experiment are listed in Table 11 for the seventeen storms which occurred in the year 1932. Hydrographs of runoff, cumulative rainfall curves, and block graphs of rainfall intensity for the storms of June 24th and October 3rd, 1932, are shown in Figures 37 and 38 respectively.

Study of the intensities of runoff as listed in Table 11, and in the hydrographs shows that in all cases the intensities from Plot 13 were fully twice as large as those from any of the terraces. These large intensities on the unterraced areas result in high velocities of flow with resultant increase in erosive power of the flowing water.

A comparison of Plot 13 and level terrace 6-E, which are located on identically the same soil and slope, and are cropped in exactly the same way for the storms of August 16th, October 3rd and 25th, and December 23rd, shows that Plot 13 lost 33.1 and 74.3 times as much soil per acre for the first two storms, that Plot 13 lost 2.26 tons per acre as compared to none from Terrace 6-E for the third storm, and that Plot 13 lost 42.0 times as much soil for the December storm.

Conclusions:-

1. A cover of woods and brush insures percolation of rainwater into the soil, thus preventing runoff and erosion.

2. Large gullies, when left unhindered in abandoned grass lands tend to enlarge from year to year and will in time completely consume the area.

[illegible]

[illegible] the [illegible] [illegible] the [illegible] storms which occurred in the year 1932. Hydrographs of runoff, cumulative rainfall curves, and [illegible] of rainfall intensity for the storms of June [illegible] and October 3rd, 1932, are shown in Figures 37 and 38 respectively.

Study of the intensities of runoff as listed in Table 11, and in the hydrographs [illegible] were fully twice as large as those from any of the terraces. These large intensities [illegible] resultant increase in erosive power of the flowing water.

A comparison of Plot 13 and level terrace C-2, which are located [illegible] shows that Plot 13 lost 33.1 and 74.7 times as much soil per acre for the first two storms, that Plot 13 lost 2.35 tons per acre as compared to none [illegible]

Conclusions:-

1. A cover of woods and brush insures percolation of rainwater into the soil, [illegible]

2. Large gullies, when left unhindered in abandoned grass lands [illegible]

[illegible]

TABLE No. 11

Small Watersheds With Different Characteristics
Measurements of Rainfall, Run-off, and Soil Loss For Principal Storms During the Year 1932
Red Plains Soil Erosion Experiment Station Near Guthrie, Oklahoma

Date of Storm	Average Rates of Rainfall 5 Min.	10 Min.	15 Min.	20 Min.	30 Min.	Total Rainfall for Storm Period	Maximum Rates of Run-off: Plot 13 Sec. Feet	Plot 13 In/Hr.	Plot 15A Sec. Feet	Plot 15A In/Hr.	Ravine A Sec. Feet	Ravine A In/Hr.	Plot J Sec. Feet	Plot J In/Hr.	Plot L Sec. Feet	Plot L In/Hr.	Terrace 6-E Sec. Feet	Terrace 6-E In/Hr.	Total Run-off In Per Cent of Total Rainfall: Plot 13	Plot 15-A	Ravine A	Plot J	Plot L	Terrace 6-E	Soil Loss in Tons Per Acre: Plot 13	Plot 15-A	Plot J	Terrace 6-E	Remarks (Crops, Soil, etc.)
January [illegible]	0.48	0.48	0.44	0.39	0.34	2.22	0.61	0.17	0.58	0.18	6.56	0.18	0.61	0.12	a	a	e	e	9.35	16.7	27.3	8.1	a	e	0.37	0.12	a	e	[illegible]
" [illegible]	0.36	0.30	0.28	0.27	0.28	0.74	a	a	0.06	0.02	0.97	0.03	a	a	a	a	e	e	a	3.3	[illegible]	a	a	e	a	[illegible]	a	e	of timber, brush, and grass.
" [illegible]	0.72	0.60	0.56	0.51	0.42	1.13	1.05	0.29	0.51	0.16	8.13	0.23	0.41	0.08	0.03	0.01	e	e	18.40	34.3	41.3	11.3	[illegible]	e	1.21	0.24	0.001	e	[illegible] of native sod cut with [illegible]
Feb. [illegible]	2.16	1.80	1.40	1.17	0.88	0.50	1.40	0.38	0.20	0.06	1.12	0.03	0.31	0.06	a	a	e	e	9.86	[illegible]	6.3	2.7	a	e	0.77	0.02	a	e	Terrace 6-E is a level ter- [illegible]
May 31	6.00	4.68	4.20	4.35	3.84	2.96	22.53	6.17	7.49	2.38	61.53	1.72	9.54	1.80	0.61	0.11	e	e	70.60	32.1	[illegible]	[illegible]	1.3	e	14.52	3.27	0.006	e	feet vertical spacing, Plot 13 [illegible]
June 3	0.96	0.84	0.64	0.63	0.52	0.81	0.54	0.15	0.14	0.05	3.56	0.10	a	a	a	a	e	e	21.60	5.7	[illegible]	a	[illegible]	e	a	0.11	a	e	cultivated land not terraced, [illegible]
" 4	2.28	1.86	1.68	1.44	1.14	1.59	6.80	1.86	2.96	0.94	[illegible]	0.62	3.44	0.65	0.23	0.04	e	e	74.60	56.0	[illegible]	28.2	[illegible]	e	[illegible]	1.60	[illegible]	e	races on 3.13 acres of culti- [illegible]
" 5	1.92	1.68	1.64	1.44	[illegible]	0.73	[illegible]	0.99	1.08	0.34	[illegible]	0.62	1.05	0.20	0.06	0.01	e	e	60.30	[illegible]	[illegible]	9.7	1.2	[illegible]	[illegible]	0.47	0.006	e	area comprises 35 acres of [illegible] These four
" 23	1.92	1.56	1.44	1.38	1.32	0.90	1.37	0.37	0.35	0.11	[illegible]	0.06	0.93	0.18	0.03	0.01	e	e	13.30	[illegible]	[illegible]	[illegible]	[illegible]	e	2.72	0.13	a	e	Plots supported winter wheat [illegible]
" 24	4.80	3.84	3.60	3.54	[illegible]	2.84	20.76	5.33	8.49	2.69	67.05	1.98	13.63	2.37	4.06	0.70	e	e	94.30	[illegible]	[illegible]	[illegible]	[illegible]	e	[illegible]	5.05	[illegible]	e	months of 1931-32 and were [illegible]
" 26	0.48	0.36	0.32	0.30	0.28	0.83	0.31	0.08	0.22	0.07	4.05	0.11	a	a	0.02	0.01	e	e	30.20	14.2	30.0[b]	a	1.1	e	1.18	0.02	0.012	e	during the first week of April 1932. Cotton was
" [illegible]	1.56	1.02	0.84	0.84	0.72	0.42	1.37	0.58	0.99	0.31	[illegible]	0.45	0.93	0.17	a	a	e	e	50.50	[illegible]	49.2	17.4	a	e	2.39	0.13	0.044	e	planted in contoured rows on [illegible], cultivated on
July 5	4.56	3.72	2.88	2.34	1.64	1.76	[illegible]	5.93	[illegible]	2.69	[illegible]	1.63	13.18	2.47	1.37	0.24	e	e	53.50	[illegible]	[illegible]	[illegible]	10.3	e	15.20	2.34	0.019	e	June 15 and July 20, and [illegible] completed on
[illegible]	[illegible]	2.64	2.24	1.92	1.52	[illegible]	[illegible]	[illegible]	0.24	0.08	21.24	0.60	1.44	0.27	0.25	0.04	d	d	17.50	9.4	40.0[b]	[illegible]	0.9	10.0	5.63	0.34	a	0.17	October 14, 1932. A cover [illegible]
[illegible]	[illegible]	3.72	2.96	2.40	1.70	1.02	19.55	5.35	d	d	[illegible]	0.44	1.05	0.20	0.30	0.05	0.49	0.45	54.50	[illegible]	[illegible]	5.1	0.9	15.8	4.46	0.45	a	0.06	[illegible] on October 17, [illegible].
" [illegible]	[illegible]	[illegible]	2.88	2.25	1.52	2.14	3.40	0.93	0.90	0.29	0.90	0.03	a	a	a	a	a	a	27.00[b]	13.5	5.6	a	a	a	2.26	0.20	a	a	
[illegible]	[illegible]	[illegible]	0.44	0.42	0.38	2.78	0.93	0.25	0.23	0.07	1.20	0.03	a	a	a	a	0.12	0.10	42.80[b]	8.7	15.0[b]	a	a	14.4	3.42	0.05	a	0.08	-

Plot	Land Slope
13	[illegible].13
15 A	[illegible].42
Ravine A	4.94
J	[illegible]
L	4.[illegible]

Note:
a - No run-off or no soil loss
b - Total run-off estimated
d - No record due to instrument failure
e - Silt sampling unit and Recorder not installed

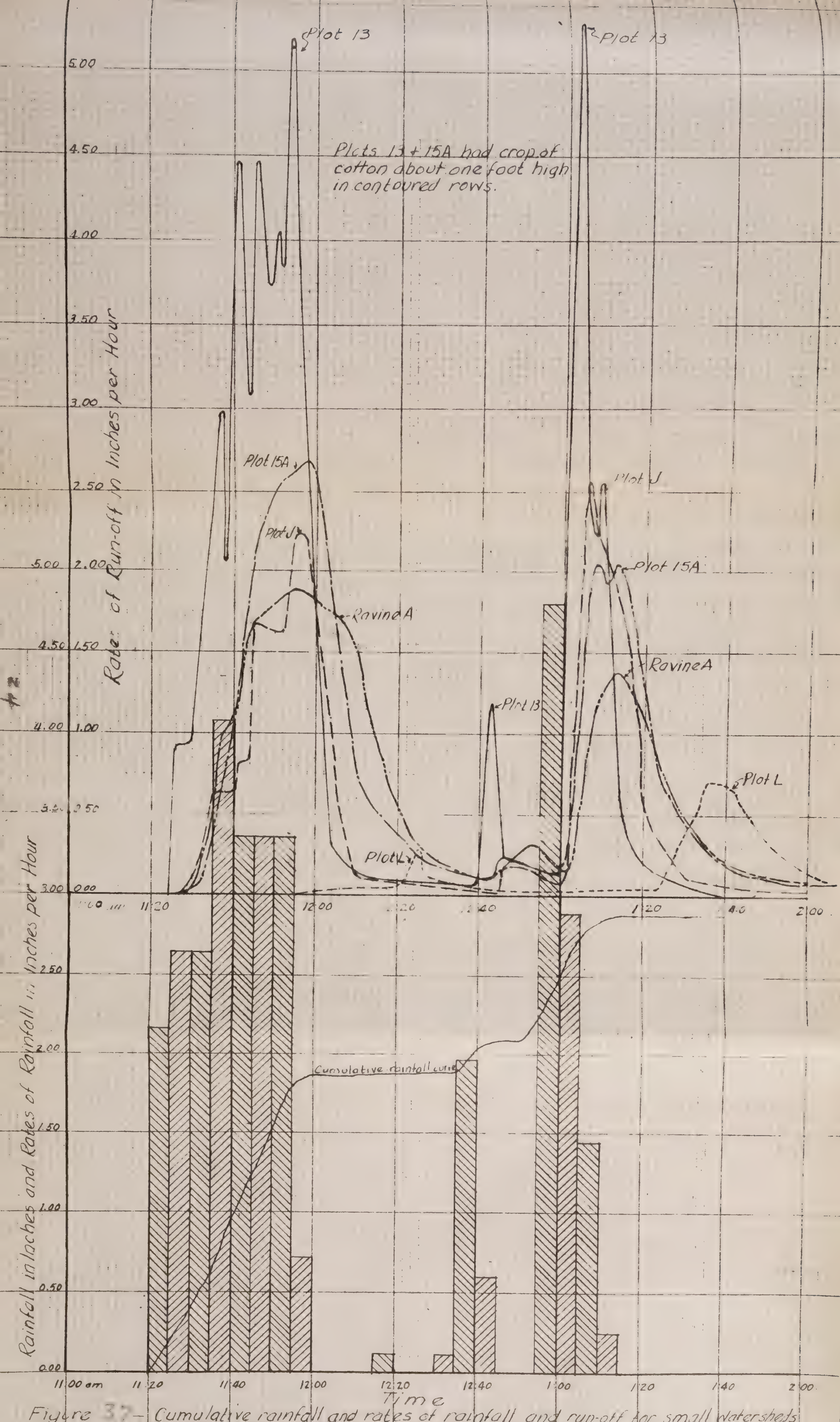

Figure 37 – Cumulative rainfall and rates of rainfall and run-off for small watersheds with different characteristics, as follows:- Plot L = 5.6 acres, wooded; Plot J = 5.3 acres, gullied grass land; Plot 13 = 3.6 acres, cultivated and not terraced; Plot 15A = 3.1 acres, cultivated, with five level terraces; Ravine A = 35.0 acres of terraced land. Landslopes vary from 3.5' to 5' per 100'. Rain of June 24, 1933.

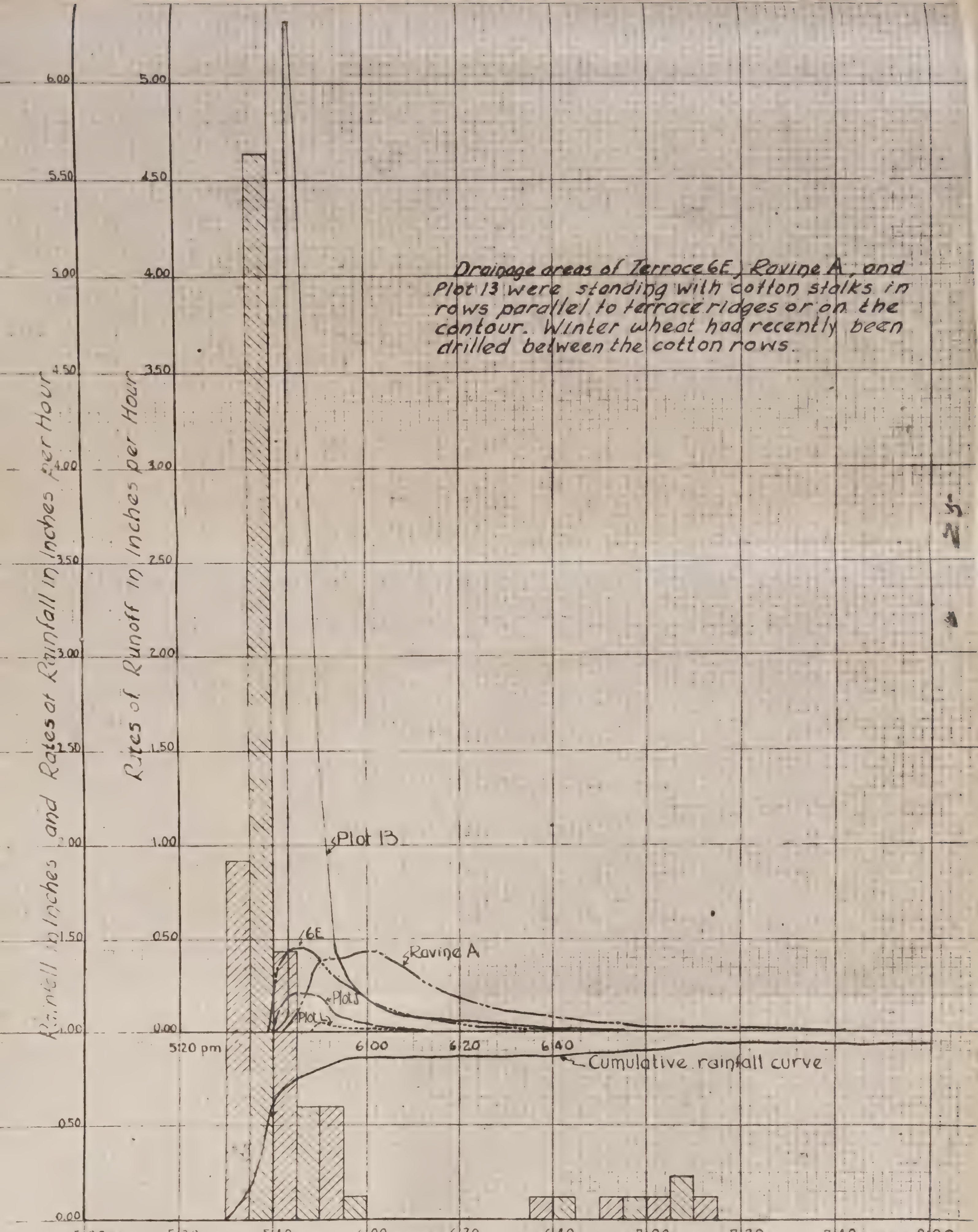

Figure 38 – Cumulative rainfall and rates of rainfall and runoff for small watersheds with different characteristics, as follows — Plot L = 5.6 acres, wooded; Plot J = 5.3 acres, gutted grass land; Plot 13 = 3.6 acres, cultivated and not terraced; Ravine A = 35.0 acres of terraced land. Landslopes vary from 3.5 to 5.0' per 100'. Rain of October 3, 1932.

3. Runoff in per cent of rainfall, from gullied grass lands is much higher than runoff from areas with unbroken cover and is less than from cultivated areas.

4. Percentage of rainfall appearing as runoff on cultivated areas with level terraces is less than the runoff from areas with graded terraces or from fields not terraced.

5. Conservation of moisture by level terraces on the eroded Vernon soil of the Guthrie station caused decreased crop yields during the four years of record by drowning of the crops in the terrace channels.

6. The per cent of rainfall which ran off unterraced and cultivated Plot 13 was about the same as the per cent figures on the graded terraces.

7. Soil loss from Plot 13 was at nine times the rate of loss from a terrace one-half mile long with a variable grade from 0" to 4"/100', 12.5 times the rate of loss from a terrace 1,500 feet long with a constant grade of 4"/100', 25 times the rate from a level terrace 1,500 feet long and at a rate varying from 33 to 74 times the loss from a short level terrace under exactly comparable conditions.

E X P E R I M E N T N O. 13.

Subsoiling Terraced and Unterraced Land.

As has been stated under Experiment No. 4, a subsoiling experiment was conducted on terraces 1-F and 2-F. The north portion of the terraces was subsoiled to a depth of about 14 inches and the south portion was plowed in the usual manner. The subsoiling was done in the fall of 1929 and was repeated again in the early part of 1932. From the crop yield records listed under Experiment No. 4, it may be seen that the subsoiling caused no increase in yields. The water standing in the subsoiled portions of terraces 1-F and 2-F disappeared about four days, or 19 per cent earlier in 1931 than was the case on the land plowed in the usual manner. This time element was apparent in about the same ratio for the year 1932. This slight shortening of total time after rains before farm operations can be resumed, would not justify the expense of subsoil plowing. It may be, however, that in years of very low rainfall the effect of subsoiling this particular type of land would be sufficient to justify the operation. Further data must be obtained before conclusions can be drawn. Another experiment to determine the effect of subsoiling was conducted on a neighboring farm. An area of 5.98 acres was obtained for this purpose, and a gully running roughly north and south through the central part of the area was selected as a division line between the two plots. The west plot, amounting to 3.31 acres, was subsoiled to a depth of about 14 inches and the east plot of

2.67 acres was plowed in the usual manner. The slope of this land is quite uniform and averages about 4.5 per cent. The total area was planted to cotton during the years 1930 and 1931 and a record of yields was kept.

LINT COTTON YIELDS (In pounds)

Plot	1930 Yield	1931 Yield
Subsoiled	84 per acre	82 per acre
Normal	73 per acre	72 per acre

This difference in yield of approximately 10 pounds of lint cotton per acre cannot be entirely attributed to the subsoil operation since a soil survey indicates that the plot which was subsoiled has a slightly better soil than the non-subsoiled plot. Even if this were not the case an increase as small as recorded would not justify the added cost of subsoil plowing with cotton selling from 6¢ to 10¢ per pound.

2.87 acres was placed in the cotton program. The slope of this land is quite uniform and averages about 4.5 per cent. The check area was planted to cotton during the years 1930 and 1931 and a record of yields was kept.

LINT COTTON YIELDS (In pounds)		
Plot	1930 Yield	1931 Yield
Subsoiled	84 per acre	81 per acre
Normal	73 per acre	72 per acre

This difference in yield of approximately 10 pounds of lint cotton per acre cannot be entirely attributed to the subsoil operation since a soil survey indicates that the plot which was subsoiled has a slightly better soil than the non-subsoiled plot. Even if this were not the case an increase as small as indicated would not justify the added cost of subsoil plowing with cotton selling from 5¢ to 10¢ per pound.

E X P E R I M E N T N O. 14.

Tile Drainage of Level Closed End Terraces.

This experiment will afford information on the effectiveness of a tile drainage system when applied to level terraces designed to retain all the rain water. In the early months of 1932, a tile drainage system was installed on the portion of terrace 2-F that lies south of the central dividing levee. This is the area that is plowed in a normal manner to compare with the subsoiled area north of the levee.

Forty feet of drain tile four inches in diameter were laid in the channel of Terrace 2-F at the extreme south curve, and covered with loose rock to a depth of one foot. About one foot of topsoil was placed above the rock. The outlet "T" was placed at the center of the forty foot section and was concreted in place. The outlet title line, 190 feet long, loads from the south point of terrace 2-F along the divide between Fields B and C to a point just below terraces 3-B and 2-C where it empties into an open ditch. The fall of the outlet line is four feet per hundred feet of line.

The water entered the tile rapidly after storms, but the head of the outlet line was so great that the soil above the rock inlet was forced through the openings between the rock, leaving an open ditch in the terrace channel. This trouble continued during most of the major storms of 1932. For smaller storms the tile drained the excess water from the terrace channel in a shorter time than was noted for Terrace 1-F. For storms of this type, there was not sufficient standing water in the terrace channels to give a fair measure of the efficiency of tile drainage. The tile system will be reconstructed in 1933 and further comparisons of effectiveness made.

E X P E R I M E N T   N O. 15.

Runoff and Soil Losses from Large Terraced and Unterraced Cultivated Watersheds.

This experiment affords information on volume and intensity of runoff from comparatively large fields when terraced, when not terraced, and under different conditions of soil and cover.

Terraces 1-B and 9-B inclusive, and the north ends of the A terraces comprise the Ravine A watershed which together with the drainage area of the Cottonwood River above Guthrie represent the present layout for this experiment.

A Parshall measuring flume of three foot throat width was installed near the head of Ravine A for the purpose of measuring the volume and intensity of runoff from the 35 acres of terraced land in the watershed.

The installation of the measuring flume was not completed until late in the fall of 1931, and as a result, runoff measurements are available only for the rains of November. For 8.10 inches of rainfall during November, 1931, the per cent appearing as runoff was 11.90 inches which was considerably lower than corresponding figures on unterraced Plot 13, and on most of the individual terraces in Fields A, B, and C.

Runoff measurements by seasons and for the total year 1932 are listed in Table 14. These figures compare closely with those for terraces in Fields A, B. and C, and are condiderably below those for unterraced Plot 13.

The hydrographs of runoff for the Ravine A area during the storms of June 24th, and October 3rd, 1932, are shown in Figures 37 and 38. These graphs indicate that runoff from the terraced area is of low intensity and uniformly distributed over the storm period.

An automatic water level recorder is installed on the Cottonwood River in Guthrie. A gaging station is installed in connection with this recorder and staff gages are installed for measurement of the slope of the water surface over a known course. It is planned that these measurements will give accurate knowledge of the river flow for all seasons, under different conditions of flood flow, and with various channel conditions. Samples of the flow will be taken at regular intervals after the experimental work is well under way to secure a measure of the soil carried from the drainage area of the stream. Collection of data from this experiment will not start until in the spring of 1933.

E X P E R I M E N T N O. 16.

Strip Cropping in Combination with Small Terraces.

The value of a bombination of strip cropping and small terrace ridges on land severely damaged by sheet erosion is the subjedt studied in this experiment.

The experiment is located on the east portion of Field D, (See Map, Figure 1). The land in this field, which has an average slope of about 5.5 per cent, is severely affected by sheet erosion.

Five small terraces, approximating large back-furrows, were built on the area in the latter part of 1932. The ridges were each built in seven rounds with an Oliver eighteen inch single bottom sulky plow. Upon completion they averaged about seven feet in width and were about eight inches high. The ridges are level and drain to the east.

It is the purpose of this study that everything connected with it shall be as practicable as possible and capable of construction by any farmer with the tools that he already has available foruse in his other farm work. A strip of alfalfa extends 15 feet on each side from the center of each small terrace. The interval between these small strips will be planted each year in a row crop of cotton, corn or cowpeas with the upper edge of the alfalfa strips as the base line for planting. Any short rows which may develop shall be pointed up into the lower side of the next higher alfalfa strip.

The ordinary farm practices such as plowing, cultivating, and planting will be carried out in the usual manner except that they shall be performed parallel to the alfalfa strips. The effect of this combination of erosion control methods will be measured in terms of crop yields, and, if funds permit, by the use of some type of measuring device. Records of this type will not be available until the year 1933.

EXPERIMENT NO. 17.

Gully Control Studies on Pasture Land.

To check erosion and reclaim gullies on pasture land by means of check dams, forest trees, shrubs, and native grasses is the object of this experiment.

A severely eroded 110 acre farm, abandoned for agricultural use, located east of the east fence of the erosion station was loaned by the State of Oklahoma as an experimental tract.

Groups of typical and comparable gullies have been selected with the view of comparing various methods of gully control within each group. A check against gullies with no control will also be obtained in each case. In some instances a study of mechanical methods alone, and in other, forest and shrub growth alone will be used. A combination of methods will be carried out in some gullies.

Check dams will be constructed of stone and brush obtained on the farm. The shrubs, wild plums, and buckbrush will be obtained locally. The forest trees consist principally of black locust, Chinese elm, and osege orange, native grasses, principally blue stem, will be allowed to grow and their effects on checking erosion will be observed. When trees are used they will be planted back of the dams, along the sides, and in the lower part of the gullies. They will be spaced approximately five feet apart, depending upon size. This experiment is to be put in at the lowest possible cost, to show that a farmer can do gully control work at little or no cash outlay. Which will be furnished, at no cost, by the State Forester of Oklahoma.

This is a joint project by the Bureau of Agricultural Engineering and the Bureau of Chemistry and Soils of the U. S. Department of Agriculture; and Agronomy Department of Oklahoma A. & M. College of Stillwater, Oklahoma, which is furnishing the farm on which the experiment is located; and the State Forester of Oklahoma, who is furnishing the forest trees, without cost.

The work of installing check dams will be completed in the spring of 1933. Records of cost of construction will be carefully made along with observations as to the efficiency of the various dams.

TABLE 17

Measurements of Rainfall and Run-off for Principal Storms which Occurred in 1930

Red Plains Soil Erosion Experiment Station near Guthrie, Oklahoma

Date of Rain	Average Rates of Rainfall				Maximum Rates of Run-off												Total Rainfall for Storm Period	Per Cent of Total Rainfall In Run-off						Remarks
	5 Min.	10 Min.	15 Min.	20 Min.	1 - A		2 - A		3 - A		4 - A		5 - A		6 - A			1-A	2-A	3-A	4-A	5-A	6-A	
	Inches Per Hr.	Inches Per Hr.	Inches Per Hr.	Inches Per Hr.	Second Feet	Inches Per Hr.	Second Feet	Inches Per Hr.	Second Feet	Inches Per Hr.	Second Feet	Inches Per Hr.	Second Feet	Inches Per Hr.	Second Feet	Inches Per Hr.	Inches							
April 26	3.88	2.85	2.20	1.70	.30	.51	.34	.34	.58	.42	.43	.32	.46	.49	.23	.41	.71	31.0	17.6	19.2	14.3	26.7	25.8	
May 3	6.46	5.30	5.07	4.95	3.07	5.18	4.94	4.97	6.46	4.65	5.89	4.33	*	*	2.68	4.76	3.22	74.5	68.3	63.0	64.0	*	65.8	
May 6	3.46	2.98	2.64	2.28	1.44	2.43	2.58	2.60	3.82	2.75	3.46	2.55	2.38	2.56	1.27	2.26	1.84	76.6	63.6	59.3	56.1	57.0	69.0	
May 10	5.30	3.53	2.38	1.79	1.07	1.81	2.18	2.20	4.00	2.88	3.58	2.63	2.48	2.66	1.21	2.15	.84	67.4	56.0	62.7	57.8	52.7	66.9	
May 15	2.25	1.41	1.22	1.19	.58	.98	.99	1.00	1.59	1.14	1.70	1.25	1.15	1.24	**	**	1.25	64.1	52.0	50.0	45.0	43.4	**	
May 17	3.88	2.78	2.38	2.11	1.57	2.65	2.63	2.65	3.58	2.58	3.29	2.42	2.43	2.61	**	**	1.47	84.1	79.7	74.0	69.5	72.1	**	

**Gage Removed to Install Silt Box. * Recorder not working.

Date of Rain	Average Rates of Rainfall				Maximum Rates of Run-off				Total Rainfall for Storm Period	Per Cent of Total Rainfall In Run-off		Remarks
	10 Min.	15 Min.	20 Min.	30 Min.	4 - C		5 - C			4-C	5-C	
	Inches Per Hr.	Inches Per Hr.	Inches Per Hr.	Inches Per Hr.	Second Feet	Inches Per Hr.	Second Feet	Inches Per Hr.	Inches			
April 25	2.85	2.20	1.70	1.14	.33	.12	.14	.05	.53	3.6	2.7	
May 3	5.30	5.07	4.95	4.43	8.18	2.92	5.37	2.07	2.68	64.1	56.6	some water overtopped the terraces.
May 6	2.98	2.64	2.28	1.86	5.76	2.06	4.06	1.56	1.84	60.8	58.0	
May 15	1.41	1.22	1.19	.82	2.48	.89	1.35	.52	1.22	45.2	44.0	
May 17	2.78	2.38	2.11	1.45	5.76	2.06	4.09	1.57	1.33	82.0	78.2	
May 22	1.73	1.39	1.22	.92	2.25	.80	.71	.27	.53	35.5	24.2	
June 14 and 15	1.47	.96	.81	.64	.71	.25	.43	.17	1.67	14.8	12.9	

Note: Standard soil loss measuring units were not installed until run-off producing rains for 1930 were past. Run-off measurements were made only on the terraces listed above

TABLE No. ____

Summary of Run-off and Soil Loss on All Terraces and Watersheds for the Year 1931 with Seasonal and Yearly Totals
Red Plains Soil Erosion Experiment Station near Guthrie, Oklahoma

Total Rainfall = 27.31 inches.

Terrace or Watershed No.	Drainage Area in Acres	Average Slope of Land Ft/100	Terrace: Vertical Spacing Feet	Terrace: Grade In. Per 100 Feet.	Terrace: Length Feet	Total Run-off: In Inches	Total Run-off: In Per Cent Of Total Rainfall	Soil Loss In Tons Per Acre: Total	Soil Loss: Per Inch Of Rainfall	Soil Loss: Per Inch of Run-off	Surface Condition of Watershed, crops, tillage, etc.	Crop Yield Per Acre.	Season
							FIELD A				No Run-off Occurred during the period January 1 to March 31	Bushels:	
1-A	0.59	5.35	2.00	4	700	1.80	23.37	2.32	0.302	1.292	Young corn		Apr 1 to June 30
1-A	0.59	5.35	2.00	4	700	0.03	0.91	0.02	0.005	0.549	Mature corn	7.5	July 1 to Sept 30
1-A	0.59	5.35	2.00	4	700	1.05	9.50	0.83	0.075	0.789	Bare Ground		Oct 1 to Dec 31
1-A	0.59	5.35	2.00	4	700	2.88	10.66	3.17	0.118	1.107			Total for 1931
6-A	0.56	5.60	2.00	4	700	1.34	17.40	1.27	0.165	0.948	Young corn		Apr 1 to June 30
6-A	0.56	5.60	2.00	4	700	0.27	6.98	0.16	0.041	0.596	Mature Corn	6.3	July 1 to Oct 1
6-A	0.56	5.60	2.00	4	700	3.28	29.76	0.88	0.080	0.269	Bare Ground		Oct 1 to Dec 31
6-A	0.56	5.60	2.00	4	700	4.89	18.09	2.31	0.086	0.475			Total for 1931
2-A	0.99	5.46	3.50	4	700	1.51	19.87	2.42	0.315	1.610	Young Corn		Apr 1 to June 30
2-A	0.99	5.46	3.50	4	700	0.28	7.21	0.18	0.046	0.638	Mature Corn	6.1	July 1 to Oct 1
2-A	0.99	5.46	3.50	4	700	3.11	28.22	2.01	0.182	0.645	Bare Ground		Oct 1 to Dec 31
2-A	0.99	5.46	3.50	4	700	4.90	18.13	4.61	0.171	0.943			Total for 1931
5-A	0.92	5.76	3.50	4	700	1.81	23.51	1.30	0.169	0.719	Young Corn		Apr 1 to June 30
5-A	0.92	5.76	3.50	4	700	0.30	7.64	0.18	0.046	0.602	Mature Corn	5.6	July 1 to Oct 1
5-A	0.92	5.76	3.50	4	700	3.77	34.20	1.84	0.167	0.488	Bare Ground		Oct 1 to Dec 31
5-A	0.92	5.76	3.50	4	700	5.88	21.76	3.32	0.123	0.565			Total for 1931
3-A	1.38	5.45	5.00	4	700	1.46	18.95	2.65	0.345	1.820	Young Corn		Apr 1 to June 30
3-A	1.38	5.45	5.00	4	700	0.14	3.63	0.16	0.041	1.129	Mature Corn	5.7	July 1 to Oct 1
3-A	1.38	5.45	5.00	4	700	2.85	25.85	2.99	0.271	1.048	Bare Ground		Oct 1 to Dec 31
3-A	1.38	5.45	5.00	4	700	4.45	16.46	5.80	0.215	1.306			Total for 1931
4-A	1.34	5.58	5.00	4	700	1.00	13.00	2.39	0.311	2.392	Young Corn		Apr 1 to June 30
4-A	1.34	5.58	5.00	4	700	0.16	4.05	0.11	0.028	0.690	Mature Corn	5.4	July 1 to Oct 1
4-A	1.34	5.58	5.00	4	700	2.60	23.58	1.67	0.151	0.640	Bare Ground		Oct 1 to Dec 31
4-A	1.34	5.58	5.00	4	700	3.76	13.91	4.17	0.155	1.114			Total for 1931
							FIELD B					Lbs. Of:	
1-C	6.16	3.54	3.91	0 to 4	2350	1.11	14.08	1.08	0.137	0.973	Fallow	Lint	Apr 1 to June 30
1-C	6.16	3.54	3.91	"	2350	0.14	3.57	0.10	0.025	0.714	Cotton	Cotton.	July 1 to Oct 1
1-C	6.16	3.54	3.91	"	2350	2.19	19.55	0.77	0.068	0.352	Cotton stalks	211.0	Oct 1 to Dec 31
1-C	6.16	3.54	3.91	"	2350	3.44	12.59	1.95	0.072	0.566			Total for 1931
2-B	5.99	2.79	3.99	0 to 4	2536	1.93	24.42	3.18	0.403	1.648	Fallow		Apr 1 to June 30
2-B	5.99	2.79	3.99	"	2536	0.14	3.57	0.17	0.043	1.212	Cotton		July 1 to Oct 1
2-B	5.99	2.79	3.99	"	2536	4.47	39.90	1.32	0.118	0.295	Cotton stalks	161.0	Oct 1 to Dec 31
2-B	5.99	2.79	3.99	"	2536	6.540	23.94	4.67	0.172	0.715			Total for 1931
3-B	5.67	3.70	3.45	0 to 6	2856	1.64	20.79	3.45	0.436	2.103	Fallow		Apr 1 to June 30
3-B	5.67	3.70	3.45	"	2856	0.20	5.10	0.15	0.038	0.750	Cotton		July 1 to Oct 1
3-B	5.67	3.70	3.45	"	2856	4.47	39.90	1.67	0.149	0.373	Cotton stalks	135.0	Oct 1 to Dec 31
3-B	5.67	3.70	3.45	"	2856	6.31	23.09	5.27	0.193	0.836			Total for 1931
							FIELD C					Bushels:	
3-C	2.85	4.33	3.51	6	1500	1.34	17.00	1.65	0.209	[illegible]	Young Oats	Of Oats	Apr 1 to June 30
3-C	2.85	4.33	3.51	6	1500	0.10	[illegible]	[illegible]	[illegible]	[illegible]	Mature Cowpeas	21.0	July 1 to Oct 1
3-C	2.85	4.33	3.51	6	1500	[illegible]	24.41	3.71	0.331	1.355	Fallow		Oct 1 to Dec 31
3-C	2.85	4.33	3.51	6	1500	4.15	14.35	5.46	0.186	1.310			Total for 1931
4-C	2.77	4.41	3.47	4	1500	1.34	19.31	0.74	0.094	0.481	Young Oats		Apr 1 to June 30
4-C	2.77	4.41	3.47	4	1500	0.17	3.32	0.09	0.026	0.592	Mature Cowpeas	23.0	July 1 to Oct 1
4-C	2.77	4.41	3.47	4	1500	3.13	27.91	0.99	0.088	0.316	Fallow		Oct 1 to Dec 31
4-C	2.77	4.41	3.47	4	1500	4.80	16.46	1.82	0.062	0.379			Total for 1931
5-C	2.58	4.72	3.43	2	1500	1.89	23.99	0.79	0.100	0.417	Young Oats		Apr 1 to June 30
5-C	2.58	4.72	3.43	2	1500	0.13	[illegible]	0.00	0.000	0.000	Mature Cowpeas	23.6	July 1 to Oct 1
5-C	2.58	4.72	3.43	2	1500	2.77	24.65	1.20	0.107	0.433	Fallow		Oct 1 to Dec 31
5-C	2.58	4.72	3.43	2	1500	4.79	16.42	1.99	0.382	0.415			Total for 1931
6-C	2.06	5.51	3.27	0	1500	1.14	14.47	0.63	0.030	0.552	Young Oats		Apr 1 to June 30
6-C	2.06	5.51	3.27	0	1500	0.06	1.53	0.00	0.000	0.000	Mature Cowpeas	22.8	July 1 to Oct 1
6-C	2.06	5.51	3.27	0	1500	1.95	17.39	0.62	0.055	0.318	Fallow		Oct 1 to Dec 31
6-C	2.06	5.51	3.27	0	1500	3.15	10.71	1.23	0.042	0.396			Total for 1931
							SMALL WATERSHED					Lbs. Of Threshed peas	
Plot 13	3.61	5.13	- -	- -	- -	2.05	26.00	15.88	2.014	7.746	Winter Rye		Apr 1 to June 30
"	3.61	5.13	- -	- -	- -	0.25	6.40	1.38	0.357	5.520	Mature Cowpeas	580.0	July 1 to Oct 1
"	3.61	5.13	- -	- -	- -	[illegible]	34.80	26.34	[illegible]	6.515	Winter Wheat		Oct 1 to Dec 31
"	3.61	5.13	- -	- -	- -	[illegible]	[illegible]	43.30	1.50	7.069			Total for 1931
Plot 15-A	3.13	3.42	- -	- -	- -	1.78	22.60	3.53	0.446	[illegible]	Winter Rye		Apr 1 to June 30
"	3.13	3.42	- -	- -	- -	0.05	1.30	0.09	0.023	[illegible]	Mature Cowpeas	386.0	July 1 to Oct 1
"	3.13	3.42	- -	- -	- -	3.56	31.70	3.95	0.352	1.110	Winter Wheat		Oct 1 to Dec 31
"	3.13	3.42	- -	- -	- -	5.39	19.70	7.57	0.277	1.404			Total for 1931
Ravine A	35.00	4.94	- -	- -	- -		No Record				Fallow		Apr 1 to June 30
"	35.00	4.94	- -	- -	- -		"	"			Cotton		July 1 to Oct 1
"	35.00	4.94	- -	- -	- -	1.34	11.90	No Record			Cotton stalks		Oct 1 to Dec 31
"	35.00	4.94	- -	- -	- -		Not Complete						Total for 1931
Plot J	5.28	4.44	- -	- -	- -	3.06	11.20	No	Record		Native Grass		Total for 1931
Plot L	5.62	4.80	- -	- -	- -	0.14	0.50	0.03	0.001	0.143	Woods & Brush		Total for 1931

TABLE No. [illegible]

Summary of Run-off and Soil Loss on All Terraces and Watersheds for the Year 1932 with Both Seasonal and Yearly Totals
Red Plains Soil Erosion Experiment Station near Guthrie, Oklahoma.

Total Rainfall = 36.20 inches.

Terrace or Watershed No.	Drainage Area in Acres	Average Slope of Land Ft/100	Terrace: Vertical Spacing Feet	Terrace: Grade In. Per 100 Feet	Terrace: Length Feet	Total Run-off In Inches	Run-off In Per Cent of Total Rainfall	Soil Loss In Tons per Acre: Total	Soil Loss: Per Inch Of Rainfall	Soil Loss: Per Inch Of Run-off	Surface Condition of Watershed, crops, Tillage, etc.	Crop Yield Per Acre	Season
							FIELD A					Bushels	
1-A	0.59	5.35	2	4	700	0.82	9.7	Negligible			Fallow		Jan. 1 to May 15
1-A	0.59	5.35	2	4	700	6.67	44.4	3.55	0.247	0.532	Oats	[illegible]	May 15 to July 15
1-A	0.59	5.35	2	4	700	1.41	10.6	0.02	0.001	0.014	Cowpeas		July 15 to Dec 31
1-A	0.59	5.35	2	4	700	8.90	24.6	3.57	0.099	0.401			Total for 1932.
6-A	0.56	5.60	2	4	700	0.97	11.5	0.37	0.044	0.381	Fallow		Jan. 1 to May 15
6-A	0.56	5.60	2	4	700	7.09	49.3	2.74	0.190	0.386	Oats	9.8	May 15 to July 15
6-A	0.56	5.60	2	4	700	1.92	14.4	0.47	0.035	0.245	Cowpeas		July 15 to Dec 31
6-A	0.56	5.60	2	4	700	9.98	27.6	3.58	0.099	[illegible]			Total for 1932.
2-A	0.98	5.46	3.5	4	700	0.56	6.6	0.28	0.033	0.500	Fallow		Jan. 1 to May 15
2-A	0.98	5.46	3.5	4	700	6.91	48.1	3.07	0.214	0.444	Oats	15.8	May 15 to July 15
2-A	0.98	5.46	3.5	4	700	0.52	7.9	0.19	0.014	0.365	Cowpeas		July 15 to Dec 31
2-A	0.98	5.46	3.5	4	700	7.99	[illegible].1	3.54	0.098	0.443			Total for 1932.
5-A	0.92	5.76	3.5	4	700	1.06	12.6	[illegible]	.076	0.604	Fallow		Jan. 1 to May 15
5-A	0.92	5.76	3.5	4	700	6.31	44.0	1.84	.128	0.292	Oats	6.5	May 15 to July 15
5-A	0.92	5.76	3.5	4	700	1.85	1[illegible].9	[illegible]	0.054	.389	Cowpeas		July 15 to Dec 31
5-A	0.92	5.76	3.5	4	700	9.22	25.5	3.20	[illegible]	0.347			Total for 1932.
3-A	1.38	5.45	5	4	700	0.71	8.4	[illegible]	0.057	0.676	Fallow		Jan. 1 to May 15
3-A	1.38	5.45	5	4	700	6.29	36.[illegible]	[illegible].40	0.137	0.454	Oats	21.0	May 15 to July 15
3-A	1.38	5.45	5	4	700	1.13	[illegible]	0.42	[illegible]	[illegible]	Cowpeas		July 15 to Dec 31
3-A	1.38	5.45	5	4	700	7.1[illegible]	19.8	[illegible]	0.092	0.463			Total for 1932.
4-A	1.34	5.58	5	4	700	0.66	7.1	0.32	[illegible]	[illegible]	Fallow		Jan. 1 to May 15
4-A	1.34	5.58	5	4	700	4.52	33.6	1.[illegible]	0.137	0.409	Oats	20.5	May 15 to July 15
4-A	1.34	5.58	5	4	700	1.07	[illegible]	0.51	0.038	0.477	Cowpeas		July 15 to Dec 31
4-A	1.34	5.58	5	4	700	[illegible]	18.[illegible]	2.80	0.075	[illegible]			Total for 1932.
							FIELD B						
2-C	4.37	3.66	2.93	0 to 6	2525	0.71	9.5	No Record			Cotton stalks & Winter Wheat		Jan. 1 to May 1
2-C	4.37	3.66	[illegible]	"	2525	[illegible]	24.1	[illegible]	[illegible]	1.091	Corn	15.1	May 1 to Oct 15
2-C	4.37	3.66	2.93	"	[illegible]	0.2[illegible]	[illegible]	0.05	[illegible]	0.179	Fallow		Oct 15 to Dec 31
2-C	4.37	3.66	2.93	"	2525	[illegible].39	17.[illegible]	Not Complete					Total for 1932.
1-C	[illegible]	[illegible]	[illegible]	0 to 4	2350	[illegible]	[illegible]	0.2[illegible]	[illegible]	0.362	Cotton stalks & Winter Wheat		Jan. 1 to May 1
1-C	6.16	3.54	3.91	"	2350	6.49	29.[illegible]	[illegible].33	0.283	0.975	Corn	16.7	May 1 to Oct 15
1-C	6.16	3.54	3.91	"	[illegible]	[illegible]	4.5	[illegible]	[illegible]	[illegible]	Fallow		Oct 15 to Dec 31
1-C	6.16	3.54	3.91	"	2350	7.40	2[illegible].6	6.[illegible]	0.184	0.891			Total for 1932.
2-B	5.99	2.79	3.99	0 to 4	2536	1.77	2[illegible].5	0.50	0.066	0.282	Cotton stalks & Winter Wheat		Jan. 1 to May 1
2-B	5.99	2.79	3.99	"	2536	7.98	35.7	9.73	0.435	1.[illegible]	Corn	6.1	May 1 to Oct 15
2-B	5.99	2.79	3.99	"	2536	0.42	6.7	[illegible]	.014	0.214	Fallow		Oct 15 to Dec 31
2-B	5.99	2.79	3.99	"	2536	10.17	2[illegible].1	10.32	0.285	1.015			Total for 1932.
3-B	5.67	3.70	3.45	0 to 6	2856	2.48	33.0	0.57	0.076	0.230	Cotton stalks & Winter Wheat		Jan. 1 to May 1
3-B	5.67	3.70	3.45	"	2856	8.22	36.7	9.76	0.436	1.187	Corn	6.2	May 1 to Oct 15
3-B	5.67	3.70	3.45	"	2856	0.42	6.7	0.23	0.037	0.548	Wheat		Oct 15 to Dec 31
3-B	5.67	3.70	3.45	"	2856	11.12	30.7	10.56	0.292	0.950			Total for 1932.
							FIELD C					Lbs. Of Seed Cotton	
3-C	2.85	4.33	3.51	6	1500	1.26	15.1	[illegible].64	0.077	0.508	Fallow		Jan. 1 to May 15
3-C	2.85	4.33	3.51	6	1500	6.75	32.[illegible]	14.00	0.682	2.074	Cotton		May 15 to Oct 1
3-C	2.85	4.33	3.51	6	1500	1.0[illegible]	14.8	0.42	0.058	0.38[illegible]	Cotton stalks & Winter Wheat		Oct. 1 to Dec 31
3-C	2.85	4.33	3.51	6	1500	9.09	25.0	15.06	0.414	1.657		574.7	Total for 1932.
4-C	2.77	4.41	3.47	4	1500	1.08	12.9	[illegible].34	[illegible]	[illegible]	Fallow		Jan. 1 to May 15
4-C	2.77	4.41	3.47	4	1500	7.40	[illegible]3.0	7.95	0.386	1.072	Cotton		May 15 to Oct 1
4-C	2.77	4.41	3.47	4	1500	1.13	15.5	0.19	0.026	0.168	Cotton stalks & Winter Wheat		Oct. 1 to Dec 31
4-C	2.77	4.41	3.47	4	1500	[illegible]	26.[illegible]	[illegible].76	0.242	0.912		597.1	Total for 1932.
5-C	2.58	4.72	3.43	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Fallow		Jan. 1 to May 15
5-C	2.58	4.72	3.43	2	1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cotton		May 15 to Oct 1
5-C	2.58	4.72	3.43	2	1500	1.01	13.9	0.14	0.019	0.139	Cotton stalks & Winter Wheat		Oct. 1 to Dec 31
5-C	2.58	4.72	3.43	2	1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		568.2	Total for 1932.
6-C	2.06	5.51	3.27	0	1500	0.26	[illegible]	[illegible]	[illegible]	[illegible]	Fallow		Jan. 1 to May 15
6-C	2.06	5.51	3.27	0	1500	7.35	35.8	4.0[illegible]	[illegible]	[illegible]	[illegible]		May 15 to Oct 1
6-C	2.06	[illegible]	[illegible]	0	1500	[illegible]	[illegible]	0.04	0.005	[illegible]	Cotton stalks & Winter Wheat		Oct. 1 to Dec 31
6-C	2.06	5.51	3.27	0	1500	8.44	23.3	4.06	[illegible]	[illegible]		[illegible]	Total for 1932.
							SMALL [illegible]						
Plot 13	3.61	5.13	- -	- - -	- -	[illegible]	5.5	[illegible]	0.281	[illegible]	Fallow		Jan. 1 to May 15
"	3.61	5.13	- -	- - -	- -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cotton		May 15 to Oct 1
"	3.61	5.13	- -	- - -	- -	[illegible]	[illegible].0	10.14	[illegible]	[illegible]	Cotton stalks & Winter Wheat		Oct 1 to Dec 31
"	3.61	5.13	- -	- - -	- -	11.15	30.[illegible]	[illegible].06	[illegible]	[illegible]		[illegible]	Total for 1932.
6-B	1.30	4.56	4	0	648	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].326	Cotton stalks & Winter Wheat	347.[illegible]	[illegible] to Dec 31
Plot 15-A	3.13	3.42	- -	- - -	- -	0.79	[illegible]	[illegible]	[illegible].046	[illegible].494	Fallow		Jan. 1 to May 15
"	3.13	3.42	- -	- - -	- -	[illegible]	27.4	14.[illegible]	[illegible].710	[illegible]	Cotton		May 15 to Oct 1
"	3.13	3.42	- -	- - -	- -	0.7[illegible]	10.0	[illegible].70	[illegible]	[illegible]	Cotton stalks & Winter Wheat		Oct 1 to Dec 31
"	3.13	3.42	- -	- - -	- -	7.16	19.8	15.70	0.434	[illegible]		[illegible]	Total for 1932.
Ravine A	35.00	4.94	- -	- - -	- -	1.22	14.[illegible]	No Record			Fallow		Jan. 1 to May 15
"	35.00	4.94	- -	- - -	- -	7.59	37.[illegible]	"	"		Cotton		May 15 to Oct 1
"	35.00	4.94	- -	- - -	- -	0.84	11.5	"	"		Cotton stalks & Winter Wheat		Oct 1 to Dec 31
"	35.00	4.94	- -	- - -	- -	[illegible].65	26.6	"	"				Total for 1932.
Plot J	5.28	4.44	- -	- - -	- -	[illegible].66	10.1	No Record			Native grass	- -	Total for 1932.
Plot L	5.62	4.80	- -	- - -	- -	[illegible].72	2.[illegible]	0.13	[illegible]	[illegible]	[illegible]	- -	Total for 1932.

SUMMARY OF RESULTS OBTAINED
ON
THE RED PLAINS SOIL EROSION EXPERIMENT STATION
FROM 1 9 2 9 to 1 9 3 2 INCLUSIVE

Trends and conclusions for the Guthrie Station are based on observations and measurements collected over a four-year period. All run-off measurements are based on collections for a three-year period or less, and soil loss records are complete only for the years 1931 and 1932. This brief period of time must be borne in mind in making interpretations of results.

R E S U L T S

Experiment No. 1:-

1. The per cent of the rainfall which appears as runoff decreases as the vertical spacing between terraces increases, due to the increased opportunity for percolation.

2. Soil loss in tons per acre increases directly with the vertical spacing between terraces when the ground is bare, in fallow, or cropped to clean cultivated row crops.

3. When the field is cropped to close growing drilled crops, such as oats, the soil loss is not greatly influenced by the vertical spacing.

Experiment No. 2:-

4. The per cent of the rainfall appearing as runoff decreases to a small extent with the grade of the terrace.

5. The intensity of runoff decreases decidedly with decreased grade of terrace.

6. Yearly soil loss per acre is about one fourth as much on the level terrace as on the terrace of six inch grade per 100 feet.

7. The terraces with four and six inch grades appear to retain the desired grade in excellent manner so long as the outlet is protected from scouring, while the two inch and level grades are subject to irregularities produced by channel deltas.

8. Crop yieldsis lowered on the terrace with six inch grade by scouring and is lowered on the level terrace by drowning.

Experiment No. 3:-

9. Runoff in per cent of yearly rainfall is about twice as large from terraces located on the severely eroded land contained in Experiment No. 3, as from the terraces on new land.

10. Yearly soil loss from the terraces on eroded land is approximately twice that from the terraces on new land.

11. During severe storms the absorption capacity of the new soil is overtaxed and the variation between soil loss and runoff on eroded and virgin land is not equal to the yearly average. For lesser storms, the new soil is able to absorb the moisture at a rapid rate and the variation between eroded and virgin land often exceeds the yearly average.

12. Crop yields from the terraces located on the virgin land of this experiment were from 31 to 150 per cent higher than those from the terraces on eroded land.

13. Reduction of crop productivity on the soil disturbed by the terracing operation practically disappears after the first two or three years of service to the terraces.

Experiments No. 4 and 5:-

14. Information thus far obtained upon level terraces with notoutlet on the eroded soil of the Guthrie farm dictates that they are not satisfactory because terraces of excessive height or extremely small vertical spacing are required, there is a serious decrease in crop yields due to drowning of crop in the channel and delay in harvesting operations, and wet terrace channels hinder the accomplishment of farm operations at theproper time.

15. For terraces located on virgin land, it appears that absorption takes place at a sufficiently rapid rate to prevent the necessity of unusually high terrafes or close spacings.

Experiment No. 7:-

16. Cost of terrace construction will vary greatly with the experience, skill, intelligence, and vbgor of the machinery operators.

17. Soil extremely dry and hard, or extremely moist will increase the cost of construction.

18. A vegetative covering that will clog the machinery tends to slow down the rate of construction.

19. Short terraces are more expensive to construct than long terraces due to the increased percentage of time spent in turns.

20. Cost of construction per mile of terrace, not including depreciation of machinery, will decrease as the size of the terracing machine is increased, provided sufficient traction power is always supplied.

21. It requires more time and labor to build a terrace in heavy clay than in a sandy loam soil.

22. Roots, rocks, sprouts, and stumps add materially to the cost of terracing.

23. It costs about twice as much to terrace cultivated land with small gullies as it does to terrace cultivated land of a uniform nature. This ratio rapidly increases with the number and size of the gullies.

24. Terracing costs secured on soil of one definite texture and workability will not be applicable to a soil of another texture and degree of workability.

25. On slopes of less than about four per cent, it is more economical to build terraces from both sides equally, but when the slope exceeds this amount it is cheaper to work from the upper side only.

26. The one way disc plow, using discs 26 inches in diameter, will build terraces equivalent to those built with the blade terracer in approximately the same number of rounds. Only one man is required to operate the unit of tractor and one way disc while two are required to operate the tractor and blade terracer. It is subject to a major disadvantage, however, in that it will not function efficiently on wet or very damp ground that may be easily worked with a grader.

Experiment No. 8:-

27. The major objections to existing farm implements when applied to terraced land are lack of self stabilization on steep slopes, lack of flexibility to accomodate sudden changes in surface, and impossibility of quick and ready adjustment.

Experiment No. 9:-

28. The ridge and channel yields individually, for terraces 4-B to 9-B, were higher than the interval yield in 1931, but in 1932, the channel yield was slightly below the interval yield. This was caused by ponds which formed at old gully crossings in the channel and remained there during the long series of spring rains, thus drowning out much of the crop.

Experiment No. 10:-

29. Low dams are more successful than high dams since the water falls a shorter distance below the dam and there is less tendency to erode the bottom of the gully. The pressure of water above high dams is sufficient to force out silt that has accumulated in the open spaces of the more porous dams. From the standpoint of both economy and successful operation, it is believed that a height of about 2 feet is the most satisfactory for check dams in small gullies.

30. The greater the flow of water in the gully, the stronger should be the anchorage of the dam. The flow of water in the gully depends upon the size of the drainage area. Brush dams without anchorage have not been found satisfactory. In small gullies with a very limited drainage area some form of light anchorage such as a few loose rocks should be placed on top of the brush.

31. The sides of the gully at the location of dams should be protected against washing to the top of the bank or at least as high as the water in the gully is expected to rise. The most common failure of check dams consists of erosion at one or both ends of the dam.

32. An apron should be built below impervious dams to prevent the falling water from eating back under the dam. This is also a very common cause of failure of check dams.

33. For the best results the top of one dam should be placed at the level of the bottom of the dam above. The results of the experiments showed that it would be possible to place the dams further apart than this since a fill occurred the total distance between the dams in Gullies F and G. However, it is believed that the better results will be obtained where the rule is observed.

34. The check dams should not reduce the cross-section of the gully sufficiently to cause the water to overflow the banks, as this usually results in the erosion of a new parallel gully down the slope.

35. More rapid filling above a brush dam occurs where the bottom of the gully is covered with grass, straw or other similar material, the finer brush placed next to the straw, and the larger brush placed and packed so as to reduce open spaces in the brush to a minimum. This method tends to prevent erosion along the sides or bottom of the gully which results in washing out a hole and undermining the dam.

Experiment No. 12:-

36. A cover of woods and brush insures percolation of rainwater into the soil, thus preventing runoff and erosion.

37. Large gullies, when left unhindered in abandoned grass lands, tend to enlarge from year to year and will in time completely consume the area.

38. Runoff in per cent of rainfall, from gullied grass lands is much higher than runoff from areas with unbroken cover and is less than that from cultivated areas.

39. Percentage of rainfall appearing as runoff on cultivated areas with level terraces is less than the runoff from areas with graded terraces or from fields not terraced.

40. Soil loss from Plot 13 was at 9 times the rate of loss from a terrace one-half mile long with a variable grade from 0" to 4"/100', 12.5 times the rate of loss from a terrace 1,500 feet long with a constant grade of 4"/100', 25 times the rate from a level terrace 1,500 feet long and at a rate varying from 33 to 74 times the loss from a short level terrace under exactly comparable conditions.

37. Large gullies, when left unhindered in [illegible] grass lands, tend to enlarge from year to year and will in time completely consume the area.

38. Runoff in per cent of rainfall, from gullied grass land is much higher than runoff from areas with unbroken cover and is less than that from cultivated areas.

39. Percentage of rainfall [illegible] as runoff on cultivated areas with level terraces is less than the runoff from areas with graded terraces or from fields not terraced.

40. Soil loss from Plot 13 was at 9 times the rate of loss from a terrace one-half mile long [illegible] 11.6 times the rate of loss from [illegible] grade of 4"/100', 26 times the rate from a level terrace 1,500 feet long and at a rate varying from [illegible] land under exactly comparable conditions.